

Technical & Functional Documentation

Version: 2.0 (Live Codebase Analysis)

Last Updated: 30/01/2026

Status: In Development / Testing

1. Introduction

1.1 Purpose

The purpose of this Software Requirements Specification (SRS) is to describe the functional and non-functional requirements for the **GPTK Library Management System (LMS)**. This document serves as a guide for developers, quality assurance testers, and project stakeholders to ensure that the final product meets the specified needs. It covers the system's intended behavior, interface designs, constraints, and data structures.

1.2 Scope

The GPTK LMS is a desktop-based application developed using Electron.js, React, and Node.js. It is designed to modernize and automate the operations of the GPTK Library. The system facilitates:

- **Catalog Management:** Adding, editing, and tracking books.
- **Circulation Control:** Managing issues, returns, and renewals.
- **Student Database:** Maintaining records of library members.
- **Financial Oversight:** Tracking fines and generating receipts.
- **Reporting:** Providing real-time analytics on inventory and utilization.

The system operates primarily offline (Local-First) but includes cloud synchronization capabilities for data backup.

1.3 Definitions, Acronyms, and Abbreviations

- **LMS:** Library Management System.
- **SRS:** Software Requirements Specification.
- **RBAC:** Role-Based Access Control (Admin vs. Staff).
- **ISBN:** International Standard Book Number.
- **Electron:** A framework for building native applications with web technologies.
- **SPA:** Single Page Application.
- **HOD:** Head of Department.

1.4 References

- GPTK LMS User Manual.
- GPTK LMS Test Cases Document.
- IEEE Std 830-1998: Recommended Practice for Software Requirements Specifications.

2. Overall Description

2.1 Product Perspective

Electronic management of library resources is essential for efficiency. The GPTK LMS replaces manual ledger systems with a streamlined digital interface. It is a self-contained product that integrates with:

- **Local File System:** For storing the SQLite database and logs.
- **MongoDB Atlas (Optional):** For cloud backups.
- **SMTP Server:** For sending email notifications.

2.2 Product Functions

The major functions of the system include:

1. **Authentication:** Secure login with RBAC.
2. **Inventory Management:** Full lifecycle management of books (Acquisition to Disposal).
3. **Circulation:** Barcode-enabled Issue, Return, and Renewal processes.
4. **Fine Management:** Automatic calculation of overdue/damage fines.
5. **User Management:** Administration of Staff and Student profiles.
6. **Analytics:** Dashboard metrics and downloadable PDF reports.

2.3 User Characteristics

- **Administrator (Root/Admin):** Technical or managerial staff responsible for system configuration, policy setting, and staff oversight.
- **Library Staff:** Operational staff responsible for daily transactions (issues/returns). Expected to have basic computer literacy.
- **Student:** Indirect users who receive value via emails and efficient service but do not operate the software interface.

2.4 Constraints

- **OS Compatibility:** Targeted primarily for Windows 10/11 environments.
- **Offline First:** Must function fully without an internet connection (except for emails/cloud sync).
- **Hardware:** Requires a minimum of 4GB RAM for smooth Electron performance and a standard barcode scanner.
- **Regulatory & Standards:**
 - **Data Privacy:** Student personal data (Phone/Email) must be protected and not exported without authorization.
 - **Auditability:** Financial transactions (Fines) cannot be deleted, only 'Waived' with remarks, to maintain fiscal integrity.
- **Technical Constraints:**
 - **Single Instance:** Only one instance of the application should run at a time to prevent SQLite database locks.
 - **Port Availability:** Backend requires a free port (default 3001) to function; auto-negotiation or manual override is provided.

2.5 Assumptions and Dependencies

- It is assumed that the college assigns unique Register Numbers to all students.
- The library has a barcode scanner available for efficient circulation.
- An active internet connection is required only for external API calls (e.g., retrieving book covers, sending emails).

2.6 External Interface Requirements

2.6.1 User Interfaces

- **GUI Framework:** The interface is built using **React.js** with a custom Design System (CSS Variables for themes).
- **Style Guide:** Adheres to a "Clean & Minimalist" aesthetic with dark/light mode support.
- **Responsiveness:** The layout is optimized for Desktop (1366x768 and above) but is fluid enough for 1280x720 screens.
- **Standard Elements:** Consistent use of Modals for forms, Toasts for notifications, and Data Tables for lists.

2.6.2 Hardware Interfaces

- **Barcode Scanners:** The system supports standard USB HID Barcode Scanners. Scanned input is treated as keyboard keystrokes ending with Enter .
- **Printers:**
 - **Thermal Receipt Printers:** 58mm/80mm ESC/POS command compatibility for fine receipts.
 - **Standard Laser/Inkjet:** A4 PDF generation for reports and ID cards.

2.6.3 Software Interfaces

- **Operating System:** Relies on Windows API for file system access (`fs` module) and window management.
- **Database Engine:** Direct interface with **SQLite3** engine via `sqlite3` node module.
- **Email Clients:** Interfaces with SMTP servers (Gmail/SendGrid/Outlook) via standard TCP ports (587/465).

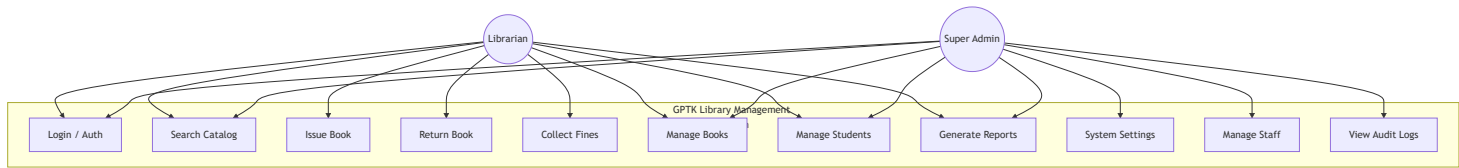
2.6.4 Communications Interfaces

- **Local Loopback:** Frontend communicates with Backend via `http://localhost:<port>` and `ws://localhost:<port>` .

- **Cloud Sync (HTTPS):** Uses encrypted HTTPS (TLS 1.2+) to communicate with MongoDB Atlas APIs.
- **Book Metadata APIs:** Connects to Google Books API / Open Library API (JSON over HTTP) to fetch book details by ISBN.

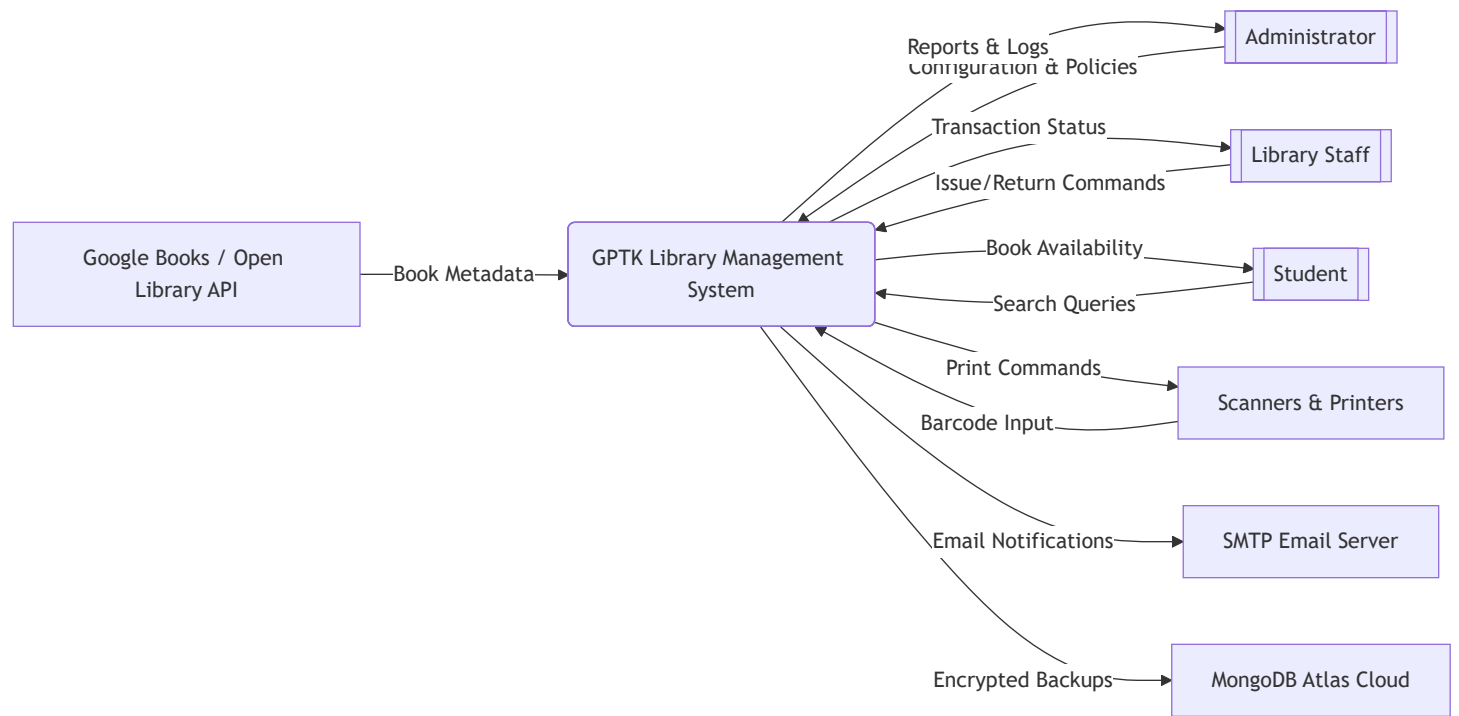
2.7 System Use Case Diagram

This diagram visualizes the primary interactions between the three key Actors (Admin, Staff, Student) and the System's major Use Cases.



2.8 System Context Diagram

This Level 0 Data Flow Diagram (DFD) illustrates the boundaries of the GPTK LMS and its interactions with external entities.



3. Functional Requirements

This section details the specific functional requirements organized by module.

3.0 Requirement Summary Table

Req ID	Feature	Priority	Description
FR-001	Authentication	High	System must support RBAC (Admins/Staff) with secure Login/Logout.
FR-002	Dashboard	Medium	Display real-time KPI cards and connection status.
FR-003	Book Management	High	CRUD operations for Books, Copy Management, and Bulk Import.
FR-004	Student Management	High	Register, Edit, Block, and Promote students.
FR-005	Circulation (Issue)	Critical	Issue books to valid students after liability checks.

Req ID	Feature	Priority	Description
FR-006	Circulation (Return)	Critical	Process returns, calculate overdue fines, and handle damaged books.
FR-007	Fines & Payments	High	Track student liabilities and generate fee receipts.
FR-008	Reports	Medium	Generate daily/monthly Transaction and Inventory reports.
FR-009	Profile Management	Low	Allow staff to change their own passwords.
FR-010	System Settings	High	Configure Fine Rates, Backup rules, and Hardware (Printers/Scanners).
FR-011	Backup & Sync	Critical	Automated local backups and optional Cloud Sync (MongoDB).
FR-012	Audit Logging	High	Log all critical data changes for security auditing.

3.1. Navigation & Layout

The application uses a persistent `MainLayout` wrapper for all dashboard routes.

- **Sidebar:**
 - **Context-Aware:** Highlights active route.
 - **RBAC Filtering:** Hides menu items based on user permissions (e.g., 'Settings' hidden for non-Admins).
 - **Collapsible:** Toggles between text+icon and icon-only modes for space efficiency.
- **Header:**
 - **Personalization:** Font Size, Language, and Theme toggles.
 - **User Profile:** Displays current user name/role.
 - **Logout:** Clears local session and redirects to Login.
- **Footer:**
 - Displays copyright year dynamic and version info.

3.2. Public Routes

- **Landing Page (/):** Gateway page.
 - **Features:**
 - **Dual-Language Support:** Toggle between English and Kannada.
 - **Appearance Controls:** Font Scalling (85-130%), Theme Toggle (Dark/Light).
 - **Restricted Access:** Login is restricted to Staff/Admins only.
 - **Accessibility:** High Contrast mode warning system.
- **Login (/login):** Unified login for Staff and Admins.
 - **Features:**
 - **Unified Access:** Accepts both Staff and Admin email credentials.
 - **Visual Feedback:** "Shake" animation on invalid credentials.
 - **Input Validation:** Highlights specific fields (Email vs Password) based on error codes (e.g., `ERR_USER_NOT_FOUND`).
 - **Session Management:** Stores JWT in `localStorage` ('auth_token') and user details ('user_info').
 - **UI Controls:** Includes Language, Font, and Theme toggles similar to Landing Page.
- **Forgot Password (/forgot-password):** OTP-based recovery.
 - **Workflow:**
 - Identity Verification:** User enters email -> System sends 6-digit OTP (via configured Email Service).
 - OTP Validation:** User enters OTP -> System verifies against DB.
 - Secure Reset:** User sets new password -> System updates hash and revokes temporary OTP.
 - **Security:**
 - **Step-Enforcement:** Users cannot jump to Step 3 without passing Step 2.
 - **Error Handling:** Specific alerts for `ERR_EMAIL_DISABLED` and `ERR_AUTH_OTP_INV` .
- **Print Report (/print/report):** Dedicated route for printing documents without UI chrome.

3.3. Dashboard Modules (/dashboard/*)

Dashboard Home (/dashboard)

The central hub for library operations, featuring **Real-Time Updates** via [Socket.io](#).

- **KPI Cards:**
 - **Total Books/Students:** Quick access to respective managers.
 - **Issued Today:** Modal view of day's issues.
 - **Overdue:** Modal view of active loans past due date.
 - **Fines:** Total collected amount (paid fines).
 - **Lost/Damaged:** Count of unavailable inventory.
- **Visual Analytics:**
 - **Pie Chart:** Book distribution by Department.
 - **Bar Chart:** Student strength by Department.
 - **Trending:** Top 5 most issued books (Vertical Bar).
- **Recent Activity:** Live stream of the last 10 system audit logs (Admin only).
- **Role-Based Visibility:** Widgets hide automatically if the user lacks permission (e.g., 'Fines' hidden if no 'CIRCULATION' access).

Catalog Management (/dashboard/books)

The central command center for library inventory. This module lists all bibliographic records and provides granular control over physical copies.

1. Toolbar & Navigation

- **Search Bar:**
 - **Scope:** Performs a real-time "fuzzy" search across **Title**, **Author**, and **ISBN** fields.
 - **Behavior:** Debounced input triggers backend query (SQL `LIKE %...%`).
- **Filters:**
 - **Department:** Dropdown to filter books by specific department (e.g., "Computer Science", "Physics"). defaults to "All Departments".
- **Sorting:**
 - **Recently Added:** Sorts by `created_at` (Descending).
 - **Title (A-Z):** Alphabetical sort.
 - **Availability:** Sorts by `available_copies` (High to Low) to quickly identify stocked items.
- **Action Buttons:**
 - **Bulk Delete (Dynamic):** Appears ONLY when one or more books are selected.
 - **Export:** Opens Export Modal.
 - **Import:** Opens CSV Import Modal.
 - **Add Book:** Opens Smart Add Modal.

2. Book List Interface (Smart Table)

- **Visuals:**
 - **Cover Preview:** Hovering over the cover thumbnail expands it for a better view.
 - **Availability Badge:** Color-coded progress bar:
 - **Green:** High Availability (>30%).
 - **Yellow:** Low Stock (<30%).
 - **Red:** Out of Stock (0 available).
- **Selection Logic:**
 - **Single Select:** Checkbox for individual rows.
 - **Global Select:** Header checkbox offers a **Smart Popup**:
 - "Select Page" (Current 10/20 items).
 - "Select All Global" (All items in database matching filter).
- **Row Actions:**
 - **View (Eye):** Opens Book Detail Modal (Read-Only view of metadata & copies).
 - **Edit (Pencil):** Opens Edit Modal to modify metadata.
 - **Manage Copies (Layers):** Opens dedicated modal for physical copy tracking.
 - **Delete (Trash):** Safe delete with dependency check.

3. CRUD Operations

- **Add Book (Smart Modal):**
 - **Auto-Fetch:** Entering an ISBN triggers a background search to Google Books/Open Library. If found, it auto-fills Title, Author, Publisher, and Cover URL.
 - **Auto-ID:** "Auto ID" button generates a unique internal ISBN (`AG-{Random}`) for items without barcodes.
 - **Initial Copies:** "Total Copies" field auto-generates that many physical records (e.g., 5 copies = `ISBN-001` to `ISBN-005`).
- **Edit Book:**

- **Constraint:** ISBN is permanently locked to preserve relational integrity.
- **Modifiable:** Title, Author, Price, Shelf Location, Cover URL.
- **Delete Book:**
 - **Safety Check:** Backend pre-check verifies if *any* copy of the book is currently Issued .
 - **Blocking:** If issued, deletion is **Rejected** with an error: "Cannot delete: X copies are currently issued."
 - **Success:** If safe, performs a **Cascade Delete** (Removes Book + All Available Copies).
 - **History:** Updates historical transaction_logs to suffix the book title with (deleted) so past reports remain accurate.

4. Physical Copy Management (Manage Copies)

- **Accession Logic:**
 - **Add Copies:** Appends new copies starting from the *last highest* accession number (e.g., if 978-005 exists, adding 2 creates 978-006 , 978-007).
- **Status Control:**
 - Toggle status of individual copies: Available â†” Lost â†” Damaged â†” Maintenance .
 - **Restriction:** Issued status is read-only here (managed by Circulation).
- **Cleanup:** Delete individual copies (e.g., if a specific volume is permanently destroyed).

5. Smart Bulk Import Modal (SmartBulkImportModal)

A sophisticated data ingestion tool handling CSV, XLSX, and XLS formats.

- **Step 1: File Upload:**
 - **Drag & Drop Zone:** Accepts files up to **20MB**.
 - **Template:** Provides a downloadable "Sample Template" with correct headers.
 - **Validation:** Blocks files exceeding size limit immediately.
- **Step 2: Intelligent Parsing & Mapping:**
 - **Fuzzy Header Matching:** Automatically maps CSV columns to DB fields (e.g., maps "Book Title" -> title , "Author Name" -> author) using a Levenshtein distance algorithm.
 - **Date Normalization:** Robustly parses dates from:
 - Excel Serial Numbers (e.g., 44562).
 - ISO formats (2024-01-20).
 - Regional formats (20/01/2024 or 20-01-2024).
- **Step 3: Preview & Clean Data:**
 - **Real-Time Validation:**
 - **Errors (Red):** Missing required fields, invalid numbers using regex.
 - **Warnings (Orange):** Potential issues like suspicious email formats.
 - **Duplicates (Purple):** Detects duplicate Keys (e.g., ISBN) within the file itself.
 - **Batch Operations Toolbar:**
 - **Find & Replace:** Bulk edit values across a selected column.
 - **Transform Text:** One-click utilities: UPPERCASE , lowercase , Title Case , Trim Whitespace .
 - **Remove Duplicates:** Instantly purges internal duplicates from the preview.
 - **Stats Bar:** Interactive filter tabs showing counts for valid , Warnings , Errors , and Duplicates . Clicking a tab filters the table view.
- **Step 4: Import Execution:**
 - **Blocker:** Import button is **Disabled** if critical Errors exist.
 - **Override:** Allows proceeding with Warnings or Duplicates (after confirmation).

6. Data Export

- **Formats:** PDF (Printable list) or CSV (Raw data).
- **Scope:** Exports either "Selected Rows" or "All Filtered Data".

Members Management (Students) (/dashboard/students)

Comprehensive module for managing student life-cycles, from admission to graduation.

1. Student List & Filters

- **Smart Table:**
 - **Columns:** #, Profile (Avatar/Initials), Name, Register No, Department, Semester, Status, Actions.
 - **Status Indicators:**
 - **Active (Green):** Good standing.
 - **Blocked (Red):** Suspended privileges (e.g., severe overdue).

- **Graduated (Purple):** Alumni status.
- **Search & Filter:**
 - **Multi-Field Search:** Context-aware search across Name and Register Number.
 - **Filters:** Drill down by **Department** and **Semester** (1-6, Alumni).
- **Selection Logic:**
 - **Global Select:** Header checkbox enables operations on the entire dataset (e.g., "Select All 1500 students") vs. just the current page.

2. Academic Promotion Structure (Smart Promotion)

- **Bulk Promote:**
 - **Logic:**
 - **Sem 1-5:** Automatically increments Semester by +1 (e.g., Sem 2 -> Sem 3).
 - **Sem 6:** Transitions to "**Alumni**" semester and sets Status to "**Graduated**".
 - **Safety:** Wrapped in a database transaction. If any record fails, the entire batch rolls back.
- **Bulk Demote:**
 - **Logic:** Reverses the promotion logic (e.g., Sem 3 -> Sem 2). "Alumni" reverts to "Sem 6" & "Active".
- **Defaulter Check:** Report available to identify students with pending books/fines before promotion (optional pre-check).

3. CRUD & Life-Cycle

- **Add Student:**
 - **Validation:** Enforces unique Register Number and Email .
 - **Fields:** Full Name, Father's Name, DOB (Required), Dept, Sem, Contact Info.
- **Edit Student:**
 - **Modifiable:** All fields except system-generated IDs. Status can be manually toggled to Blocked / Active .
- **Delete Student (Liability Protected):**
 - **Pre-Check:** System scans circulation (Active Loans) and fines (Unpaid Fines).
 - **Blocking:**
 - **If Liabilities Exist:** Deletion is **Blocked**. Error: "Cannot delete: Student has X active loans / Y unpaid fines."
 - **If Clean:** As detailed below.
 - **Anonymization (GDPR Compliance):**
 - **Permanent Delete:** Removes record from students table.
 - **History Preservation:** Updates past transaction_logs and fines history:
 - Sets student_id to NULL .
 - Appends (Deleted) to the historical student_name field (e.g., "John Doe (Deleted)").

4. Bulk Operations

- **Bulk Delete:** Accepts a list of IDs. Runs the **Liability Check** for *each* student. Only deletes those with 0 liabilities; returns error report for others.
- **Import/Export:**
 - **Import:** Uses the **Smart Bulk Import** modal (see above).
 - **Export:** Generates reports including Register No, Name, Dept, and current Status.

Department Management (/dashboard/departments)

Foundational structure for categorizing books and students.

- **Fields:** Name (Unique), Code (Unique), Description.
- **HOD Signature:** Upload digital signature for generating automated No-Due Certificates/Reports.
- **Live Counters:** Displays real-time count of **Books** and **Students** associated with each department.
- **Integrity:** Prevents deletion if linked resources exist (Foreign Key checks).

Module	Route	Controller (Backend)	Key Functionality
Catalog	/books	bookController.js	Add/Edit books, Manage Copies, Print Barcodes.
Members	/students	studentController.js	Register, Bulk Import, Promote/Demote, Liability Checks.
Departments	/departments	departmentController.js	Manage Depts, Upload HOD Signatures, Resource Counts.
Circulation	/circulation	circulationHandler.js	F1: Issue, F2: Return, F3: Renew. High-speed barcode scanning interface.
Fines	/fines	fineController.js	Track unpaid dues, Collect payments (partial/full), Waive off, Receipt Generation.

Circulation Module (/dashboard/circulation)

High-performance interface designed for speed, using **F-Keys** (F1, F2, F3) for tab switching.

1. Issue Tab (F1)

- **Student Identification:**
 - **Search:** Accepts Register Number or Name (with Auto-Complete).
 - **Digital ID View:** Displays Student Photo, Department, and **Digital Signatures** (Principal & HOD) for instant verification.
 - **Validation Logic:**
 - **Account Status:** Must be 'Active'.
 - **Loan Limit:** Checks $\text{Active Loans} + \text{Cart Size} \leq \text{Max Loans}$ (Default: 5).
 - **Liability Block:** Blocks issue if $\text{Unpaid Fines} + \text{Est. Overdue Fines} > \text{Limit}$ (Default: â,1500).
- **Book Scanning (Cart System):**
 - **Batch Issue:** Scan multiple barcodes into a "Cart" before confirming.
 - **Conflict Check:** Prevents adding duplicate copies or currently 'Issued' books.
 - **ISBN Resolution:** Auto-fetches Book Title/Author from internal DB for confirmation.
- **Completion:**
 - **Transaction:** Generates a Session ID.
 - **Receipt:** Sends an instant **Email Receipt** to the student with Due Dates.

2. Return Tab (F2)

- **Smart Search:**
 - Locate active loans by Student Name, RegNo, or **Book ISBN/Accession**.
 - **Grouping:** Displays loans grouped by Student in an accordion layout.
- **Return Modal:**
 - **Condition Reporting:**
 - **Good:** Standard return.
 - **Damaged:** Triggers fine input (Default: â,100).
 - **Lost:** Triggers fine input (Default: â,500).
 - **Fine Calculation:**
 - **Overdue:** $(\text{Days Late} * \text{Daily Rate})$.
 - **Total:** $\text{Overdue Fine} + \text{Damage/Lost Penalty}$.
 - **Replacements:**
 - **Lost w/ Replacement:** Workflow to mark old copy as 'Lost', waive the fine, and auto-accession the **new replacement copy** under the same ISBN.

3. Renew Tab (F3)

- **Policy Check:**
 - Verifies $\text{Renewal Count} < \text{Max Renewals}$ (Default: 1).
 - Checks if book is reserved (future feature).
- **Action:** Extends Due Date by Renewal Days (Default: 15) from today.
- **Audit:** Logs the renewal event in `transaction_logs` .

Financial & Fine Management (/dashboard/fines)

Detailed ledger of all financial liabilities.

- **Workflow:**
 - Detection:** Fines are generated automatically upon 'Return' (Overdue/Damage) or 'Audit' (Lost).
 - Payment Collection:**
 - Select single or multiple fines for a student.
 - **Receipt:** Auto-generates unique Receipt ID (`REC-...`).
 - **Log:** entries created in `transaction_logs` with type `FINE_PAID` .
 - Waiver:**
 - Authorized staff can "Waive Off" fines with a mandatory **Reason**.
 - Logs transaction as `FINE_WAIVED` .
- **Email Receipts:** Automatic PDF-style email sent to student upon payment/waiver.

Transaction History (/dashboard/history)

Electronic audit trail of all circulation activities.

- **Filters & Search:**
 - **Time Ranges:** Today, This Week, This Month, This Year, or All Time.
 - **Context:** Filter by Department (e.g., "Civil Engineering") or Status (ISSUE/RETURN/RENEW).
 - **Search:** Instant lookup by Student Name or Book Title.
- **Smart Table:**
 - **Columns:** Student, Book Details (Title + Accession), Date/Time, Action Type (Color-coded).
 - **Detail View:** Clicking a row reveals full metadata (e.g., Return Condition, Fine Amount, Remarks).
- **Data Export:**
 - **Formats:** PDF, CSV, Excel.
 - **Scope:** Exports either the "Current Filtered View" or "Selected Specific Rows".

Staff Management (/dashboard/staff)

Secure interface for managing library personnel and their system privileges.

- **Role-Based Access Control (RBAC):**
 - **Permissions:** Granular access control assigned per staff member:
 - **CIRCULATION** : Access to Issue/Return/Renew (F1-F3) and Fine collection.
 - **MEMBERS** : Ability to Register, Edit, or Promote students.
 - **CATALOG**: Authority to Add/Edit/Delete books and manage copies.
 - **REPORTS**: Read-only access to system analytics.
- **Security Lifecycle:**
 - **Onboarding:** New accounts are created with a default password (password123) which they must change on first login.
 - **Instant Revocation:**
 - **Disable:** Action immediately locks the account (Status -> 'Disabled') without deleting data. Useful for suspensions or long leave.
 - **Reset Password:** Admin can force-reset a forgotten password back to default.
 - **Safe Deletion:**
 - **Constraint:** Prevents deletion of the "SYSTEM" account.
 - **Data Integrity:** Before deletion, the system unlinks the Staff ID from all their past actions (Issues, Fines) by setting performed_by = NULL , preserving the audit trail without broken references.
- **Activity Monitoring:**
 - **Real-Time Stats:** Live counters for Total Staff, Active vs. Disabled, and their Total Transactions.
 - **Audit Trail:** Every action taken by a staff member is logged against their ID in transaction_logs and audit_logs .

Admin Management (/dashboard/admins)

High-level system administration and communication.

- **Root Admin Protection:**
 - **Immutability:** The primary root account (veerkotresh@gmail.com) is hardcoded to be **undeletable** and **cannot be disabled**. This prevents accidental system lockouts.
- **Admin Lifecycle:**
 - **Creation:** New admins are initialized with the default password password123 .
 - **Privileges:** All admins have full access to Staff, Catalog, and Students, but purely "Admin" management rights are equal (peer-management), except for Root protection.
- **Communication Hub (Broadcast) (/dashboard/notifications):**
 - **Composer:** Rich text editor for sending mass emails.
 - **Target Audience:**
 - **Specific Students:** Multi-select search.
 - **Overdue:** Auto-targets all students with active overdue books.
 - **Issued:** Targets all students with active loans.
 - **Channel:** Uses configured SMTP service (managed in Settings).
 - **History:** Logs all sent broadcasts with recipient count and status (Sent/Failed).

Audit Logs (/dashboard/audit)

Immutable system logs for security and compliance.

- **Scope:** Tracks Login/Logout, Staff Actions (Create/Edit/Delete), and System Errors.
- **Structure:** Each entry contains:
 - **Timestamp:** Exact time of action (IST).
 - **Actor:** Who performed the action (Name + Role).
 - **Action:** Type (e.g., CREATE , UPDATE , DELETE , LOGIN , ISSUE).
 - **Module:** Affected area (e.g., Auth , Books , Circulation).
 - **Description:** Human-readable summary.
 - **Metadata:** Technical details (JSON) like IP address or specific changed fields.
- **Features:**
 - **Detailed Filtering:** Filter by Date Range, Module, Actor Role, or Action Type.
 - **Smart Export:** Download logs as **CSV**, **Excel**, or **PDF** for external auditing.
 - **Security:** Read-only for all staff; only Root Admin can export.
 - **Real-Time:** Logs appear instantly via WebSockets.
 - | **Fines** | - | fineController.js | Fine collection, Receipt generation, Waivers. (Integrated in Return/Profile). |

Policy Manager (/dashboard/policy)

Centralized configuration for library rules and fines.

- **Borrowing Rules:**
 - **Limits:** Define Max Books per student (e.g., 5).
 - **Durations:** Set default Loan Period (e.g., 15 days) and Renewal Period (e.g., 10 days).
 - **Renewal Cap:** Restrict consecutive renewals (e.g., Max 2 times).
- **Financial Rules:**
 - **Daily Fine:** Overdue penalty rate (e.g., â,1.00 per day).
 - **Lost Book Penalty:** Fixed surcharge (e.g., â,1500) added to book replacement cost.
 - **Damaged Book Penalty:** Fixed fine (e.g., â,100).
- **Security:**
 - **Password Protected:** Any change to policy requires **Admin Password** re-entry to prevent unauthorized tampering.
 - **Version Control:** System tracks policy versions (e.g., v1.3 -> v1.4) on every save.

Settings Manager (/settings)

System-wide configuration and hardware management.

- **Appearance:**
 - **Themes:** Light, Dark, or System Sync.
 - **Accessibility:** High Contrast Mode and Font Scaling (80% - 150%).
 - **Language:** Toggle between English and Regional (Kannada - kn).
- **Hardware Integration:**
 - **Barcode Scanner:** Configure Input Mode (Keyboard/Serial) and Prefix Stripping. Includes a live test area.
 - **Printer:** Select default device (System/POS/PDF) and Paper Size (58mm/80mm/A4). Support for **Auto-Print** receipts.
- **Data Management:**
 - **Cloud Sync:** Connect to **MongoDB Atlas** for off-site backups.
 - **Smart Backup:** Detects and uploads only modified tables ("dirty tables") to save bandwidth.
 - **Automation:** Schedule backups (Daily/Weekly/On Close).
 - **Restore:** Full system restoration from Local JSON or Cloud.
- **Security:**
 - **Session:** Configure Auto-Lock timeout (default 5 mins) or Custom duration.
 - **Sensitive Actions:** Modifying Email, Backup, or Security settings requires re-entering the **Admin Password**.

System Health (/dashboard/health)

Real-time diagnostics and performance monitoring.

- **Core Metrics:**
 - **Computing:** CPU Load (%) and Memory Usage (Used/Free).

- **Storage:** Disk Space usage for the application directory.
- **Network:** Application-level internet access check (Ping `google.com`) and Latency (ms).
- **Database Health:**
 - **Connectivity:** Runs `SELECT 1` heartbeat query to ensure SQLite is responsive.
 - **Integrity:** Monitors database file size and existence.
- **Smart Score:**
 - Calculates a **Health Score (0-100)** based on resource pressure.
 - **Deductions:** -0.6 pts per 1% CPU > 50%, -1 pt per 1% Disk > 80%, -20 pts for Offline.
 - **Status:** Graded as **Optimal** (90+), **Good**, **Fair**, or **Critical**.

Department Management (/dashboard/departments)

Organize academic divisions.

- **Structure:** Manage Department Name (e.g., "Computer Science") and Code (e.g., "CS").
- **Stats:** View real-time Student and Book counts per department.
- **Actions:** Create, Edit, Delete (with confirmation safety).

Fine Management (/dashboard/fines)

Centralized financial oversight.

- **Status View:** Tabbed interface for **Pending** (Unpaid) vs **History** (Paid/Waived) fines.
- **Collections:**
 - **Cash Payment:** Collect fines and generate an instant **Digital Receipt**.
 - **Waivers:** Admin override to waive fines with a mandatory "Reason" for audit trails.

Authentication & Public Access

- **Landing Page (/):** Public portal with "Access Portal" gateway.
- **Login (/login):** Secure entry.
 - **Features:** Shake animation on error, Visibility toggle, and Language/Theme/Font controls.
- **Forgot Password (/forgot-password):**
 - 3-Step Flow: Email Verify -> OTP -> Reset Password.
 - security: Checks if email service is enabled in settings before attempting.

User Profile (/dashboard/profile)

Self-service account management.

- **Overview:** View assigned Role, Designation, and Email.
- **Security:** Change Password functionality (requires Old Password verification).

Reports & Analytics (/dashboard/reports)

Comprehensive statistical overview of library performance.

- **Three-Pillared Analytics:**
 - Circulation Reports:**
 - **KPIs:** Active Issues, Monthly Returns, Critical Overdue count.
 - **Trend Chart:** Comparative line graph of Issues vs. Returns (7/30/90 Days).
 - **Top Movers:** "Top 5 Most Borrowed Books" leaderboard.
 - Financial Reports:**
 - **Ledger:** Total Collected vs. Pending vs. Waived amounts.
 - **Revenue Trend:** Daily collection graph.
 - Inventory Reports:**
 - **Valuation:** Total asset value estimation.
 - **Distribution:** Pie charts showing "Books by Department" and "Copy Status" (Available/Issued/Lost).
- **Real-Time Data:**
 - Dashboards update instantly via **WebSockets** when any circulation/fine event occurs.
- **Export & Print:**
 - **One-Click Print:** Generates a clean, stripped-down version of the report for thermal/A4 printing.

- **CSV/PDF Export:** Download raw statistical data for external analysis.

Audit Logs (/dashboard/audit)

Immutable system logs for security and compliance.

- **Scope:** Tracks Login/Logout, Staff Actions (Create/Edit/Delete), and System Errors.
- **Security:** Read-only for all staff; only Root Admin can export.
- | **System Health** | /health | healthController.js | Diagnostics for DB status, API latency, and disk usage. |

4. Non-Functional Requirements

4.0 Requirement Summary Table

Req ID	Category	Priority	Description
NFR-001	Performance	High	Dashboard load < 2s; Scanner input < 100ms.
NFR-002	Availability	Critical	100% Offline functionality for core circulation.
NFR-003	Reliability	High	Zero data corruption on crash (WAL mode); Automated backups.
NFR-004	Security	Critical	Bcrypt password hashing; Role-Based Access Control (RBAC).
NFR-005	Usability	Medium	Accessibility (High Contrast) and Function Key support.
NFR-006	Scalability	Medium	Support 50,000+ Book records without UI lag.
NFR-007	Compliance	High	Audit logs for all financial/security actions.
NFR-008	Portability	Low	Portable AppData structure for easy migration.

4.1 Performance Requirements

- **Response Time:** Application should load to the Dashboard within 2 seconds.
- **Scanner Input:** Barcode processing (Scan to Cart) must occur within 100ms.
- **Database:** SQLite queries for "Verify Borrower" must execute in <50ms.

4.2 Reliability & Availability

- **Offline Mode:** The system (Issue/Return) must function 100% offline.
- **Crash Recovery:** Application must restart without data corruption (SQLite WAL mode).
- **Backup:** Automated "Smart Backup" to local disk on every application close.

4.3 Security Requirements

- **Password Hashing:** All user passwords must be hashed using bcrypt.
- **RBAC enforcement:** API endpoints must verify `access_permissions` for every request.
- **Configuration Locking:** Critical settings must require re-entry of Admin Password.

4.4 Usability

- **Accessibility:** Support for High Contrast Mode and Font Scaling.
- **Keyboard Support:** Full operation via Function Keys (F1, F2, F3).
- **Localization:** English and Kannada support.

5. Functional Design Specification (FDD)

This section details how the user interacts with the system, including strict Role definitions, Business Rules, and Screen Flows.

5.1. User Roles & Permissions (RBAC)

The system enforces strict security boundaries using a tiered Role-Based Access Control model.

5.1.1 User Role Definitions

- Super Admin ("Root"):** Has unrestricted access to all modules, including system configuration, security policies, and database backups. Can manage other staff accounts.
- Librarian (Staff):** Focused on day-to-day operations. Can issue/return books, manage students, and view catalogs. **Cannot** delete audit logs, change fine policies, or access system health settings.
- Student / Guest:** Indirect users who utilize library resources. They do not have system access or direct interaction with the application interface.

5.1.2 Permission Matrix

Module	Super Admin	Librarian
Auth	Login / Reset Others	Login / Reset Self
Circulation	Issue / Return / Override	Issue / Return
Catalog (Books)	Add / Edit / Delete	Add / Edit
Students	Create / Edit / Block	Create / Edit
Fines	Collect / Waive	Collect Only
Staff Mgmt	Full Access	No Access
Settings	Full Access	Read Only
Reports	Generate / Export	Generate
Audit Logs	View / Export	No Access

5.2. Use Case Descriptions

Detailed breakdown of primary system interactions.

Table 5.2.1: Issue Book (UC-01)

Field	Description
Use Case ID	UC-01
Use Case Name	Issue Book
Actors	Librarian (Staff), Administrator
Pre-Conditions	1. Student account is 'Active'. 2. Book status is 'Available'. 3. Student has not exceeded borrowing limit.
Trigger	Staff scans Student ID card or enters Register Number.
Main Flow	1. Identify: System fetches Student Profile. 2. Validate: System checks for Unpaid Fines > Limit. 3. Scan: Staff scans Book Barcode(s). 4. Commit: Staff clicks 'Issue Books'. 5. Update: System updates Book -> 'Issued', creates Loan Record. 6. Notify: Email receipt sent to Student.
Post-Conditions	Book is marked 'Issued'; Due Date is set; Inventory count decreases.

Field	Description
Exceptions	E1: Book Reserved: Alert staff, block issue. E2: Fine Limit Exceeded: Block issue until fine is paid.

Table 5.2.2: Return Book (UC-02)

Field	Description
Use Case ID	UC-02
Use Case Name	Return Book
Actors	Librarian (Staff), Administrator
Pre-Conditions	Book is currently marked as 'Issued'.
Trigger	Staff scans Book Barcode at Return Desk.
Main Flow	1. Scan: Staff scans Book Barcode. 2. Calculate: System calculates Duration & Overdue Fines. 3. Assess: Staff checks physical condition (Good/Damaged). 4. Commit: System processes return. 5. Settlement: If Fine > 0, Add to Student Ledger. 6. Notify: Email receipt sent to Student.
Post-Conditions	Book is 'Available'; Student loan count decreases; Fine added (if any).
Alternate Flows	A1: Lost Book: Staff creates 'Lost' transaction; Cost added to student dues.

5.3. Business Rules

- **BR-01 (Liability Limit):** Students cannot borrow new books if pending fines exceed \$500.
- **BR-02 (Renewal Cap):** A specific book copy can be renewed max 3 times consecutively.
- **BR-03 (Admin Override):** Only Admins can waive fines > \$100; Staff is limited to waivers < \$100.
- **BR-04 (Safe Delete):** Students with unreturned books cannot be deleted/archived.
- **BR-05 (Audit Trail):** Financial records (Fines) are immutable; they can only be marked 'Paid' or 'Waived', never deleted.

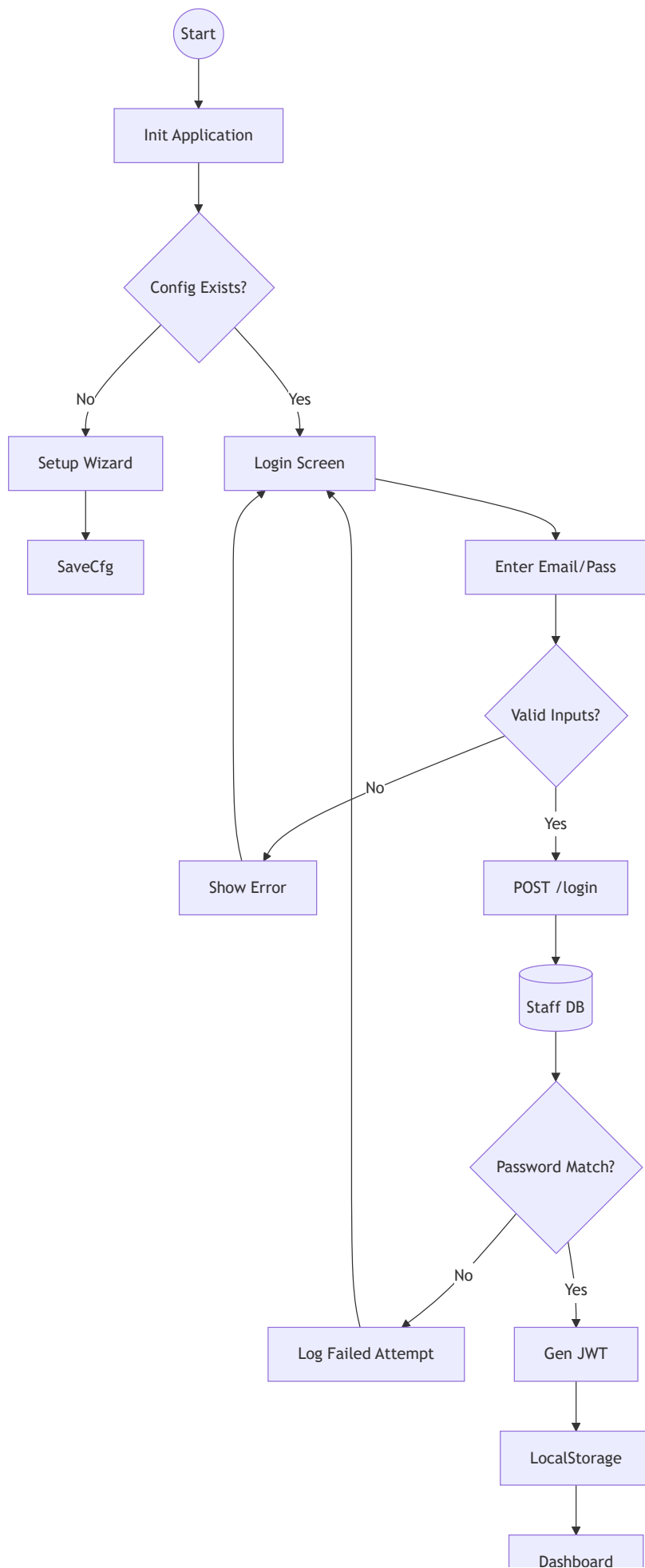
5.4. Screen Flow (Navigation Logic)

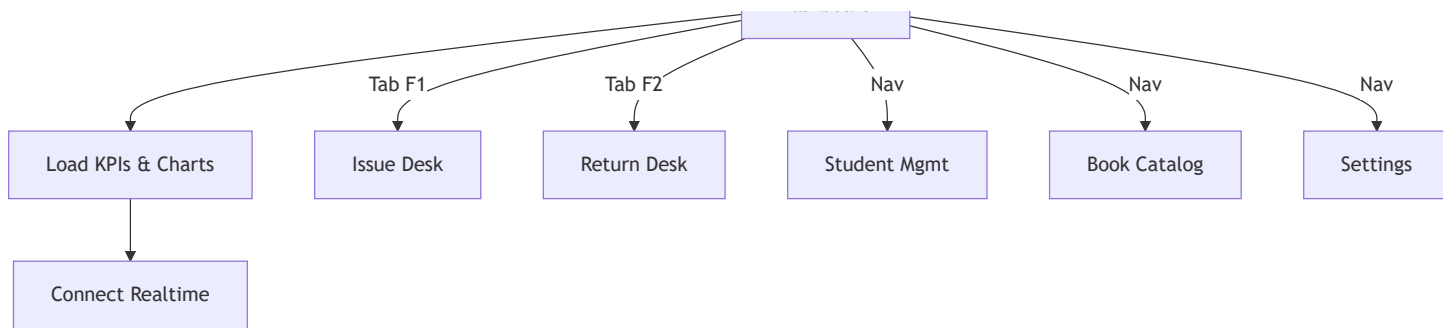
- **Public:** Landing -> Login -> (Auth Check) -> Dashboard.
- **Circulation:** Dashboard -> Circulation Desk -> (Scan ID) -> Student Profile -> (Scan Book) -> Checkout.
- **Report:** Dashboard -> Reports -> Select Date Range -> Preview -> Export PDF.

5.5. Detailed Activity Diagrams

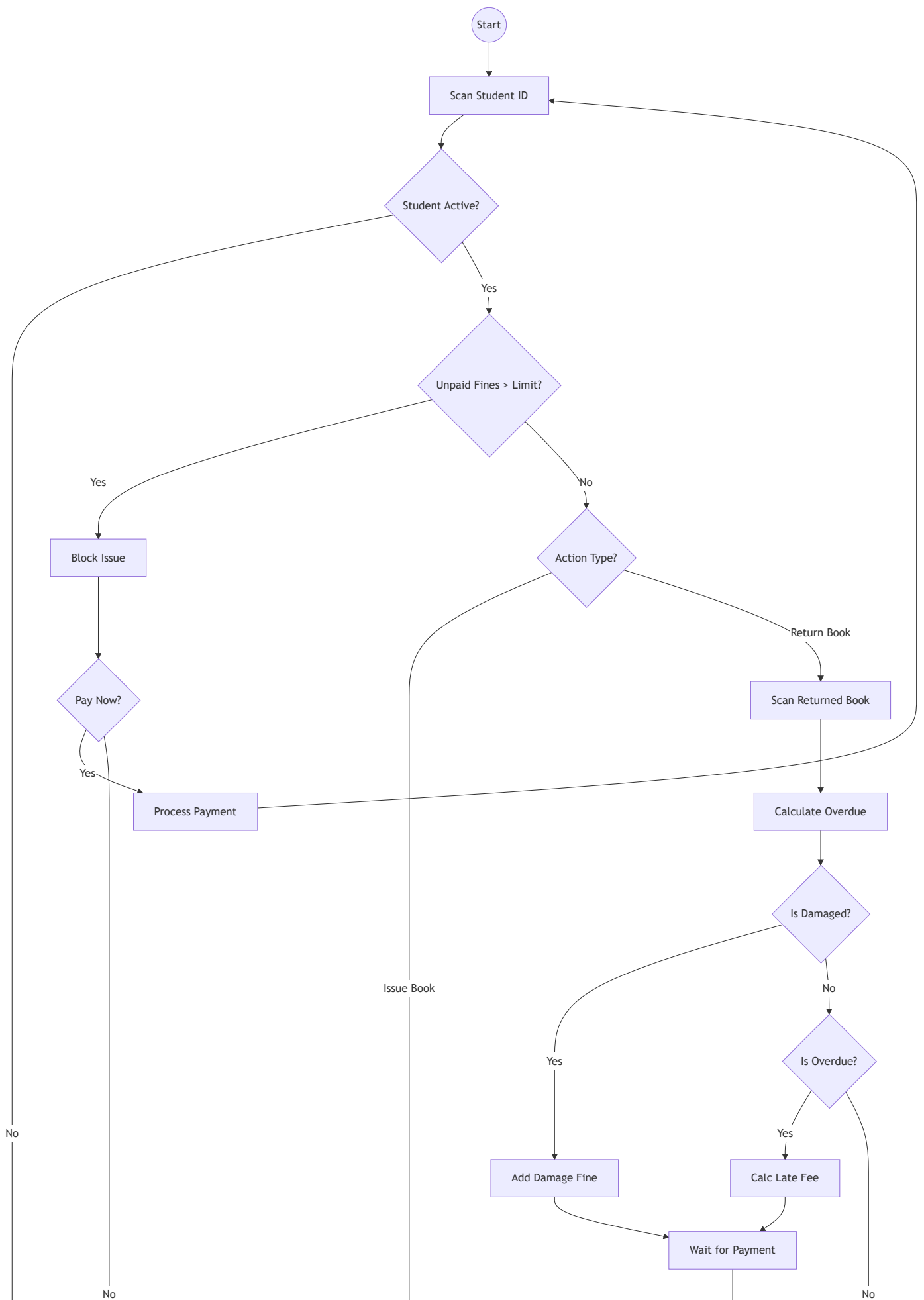
5.5.1 Master Operational Workflow

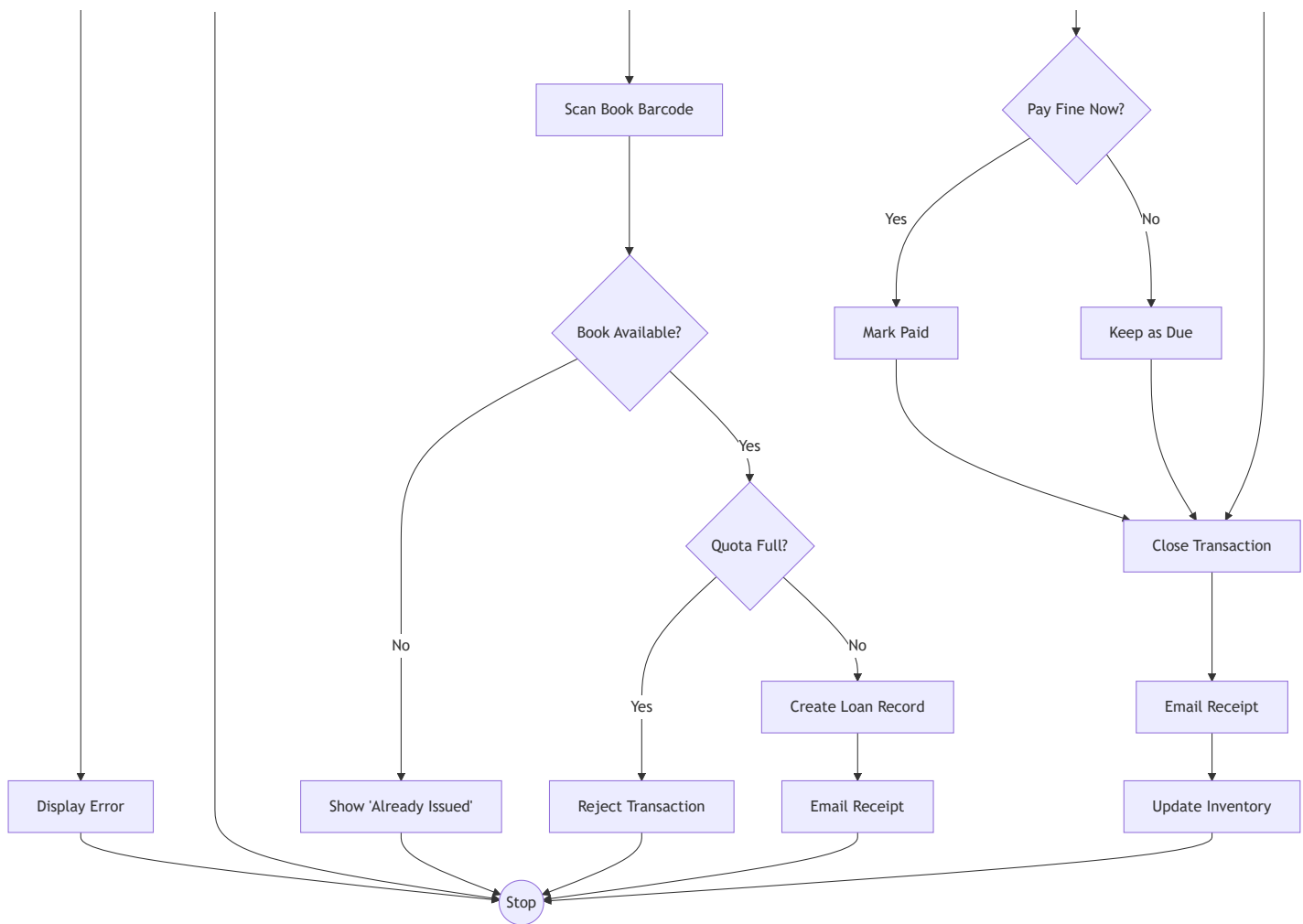
This comprehensive map details the complete system lifecycle.





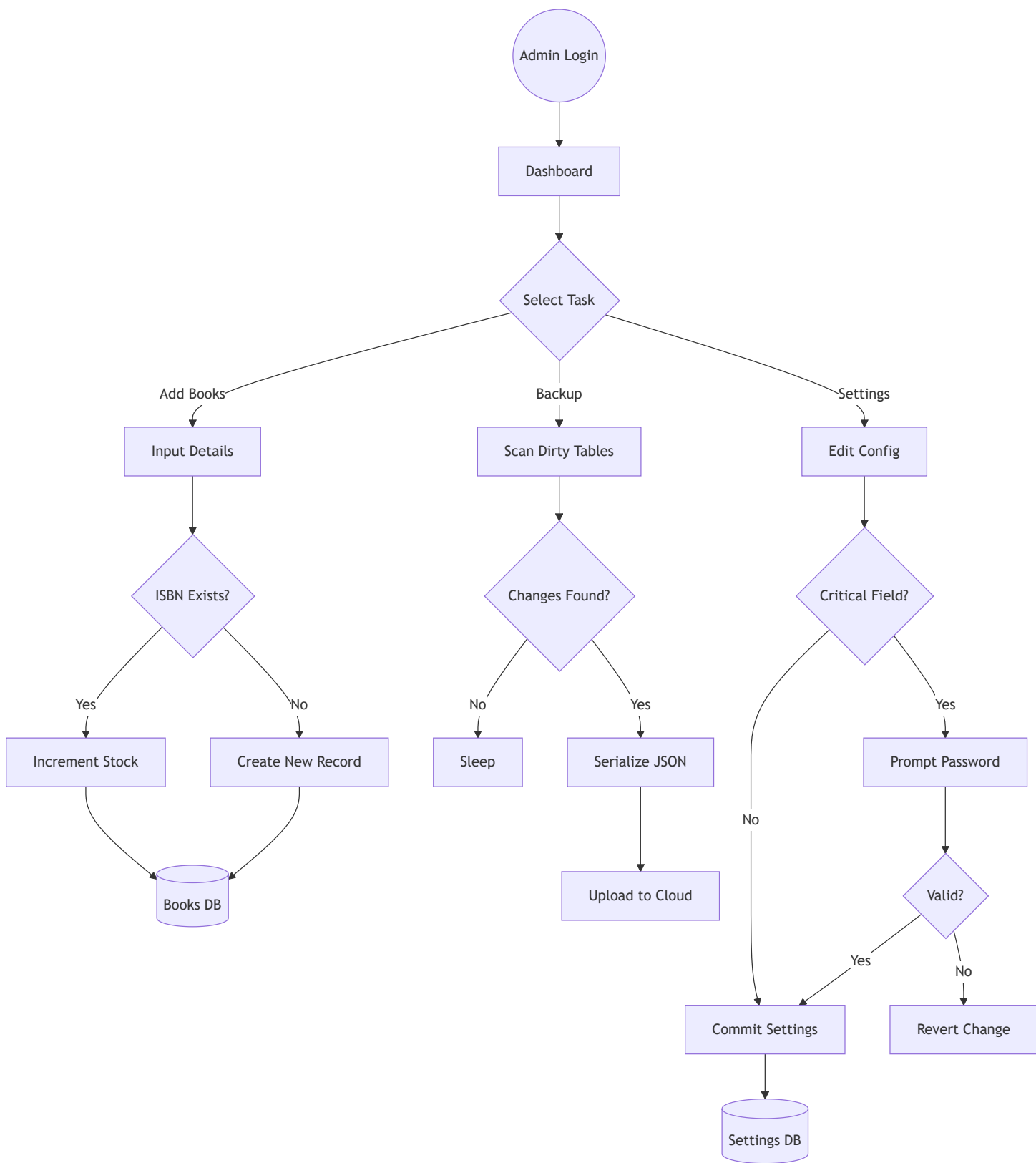
5.5.2 Core Circulation Activity (Issue / Return Cycle)



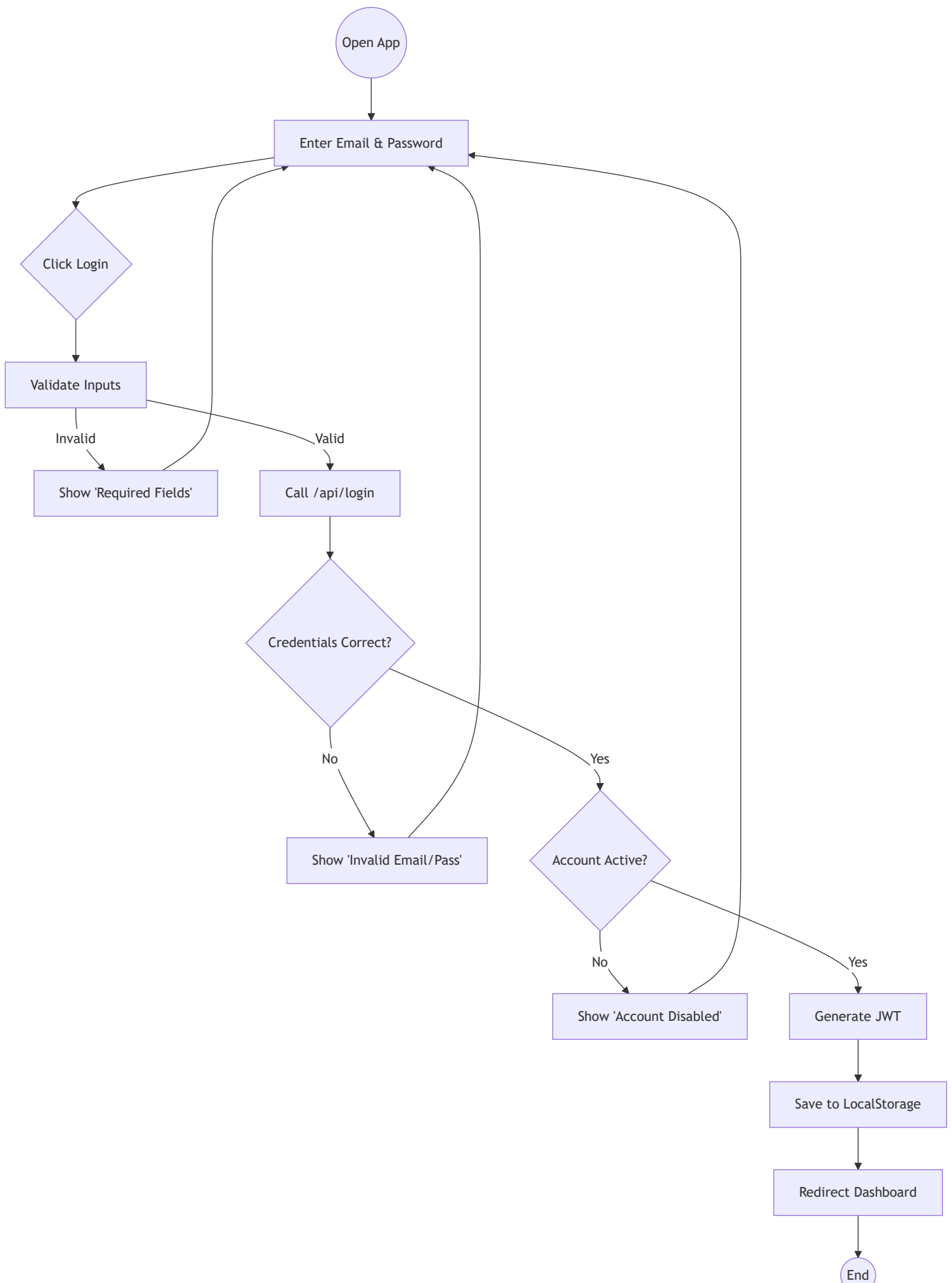


5.5.3 Data Management Pipeline (Admin Ops)

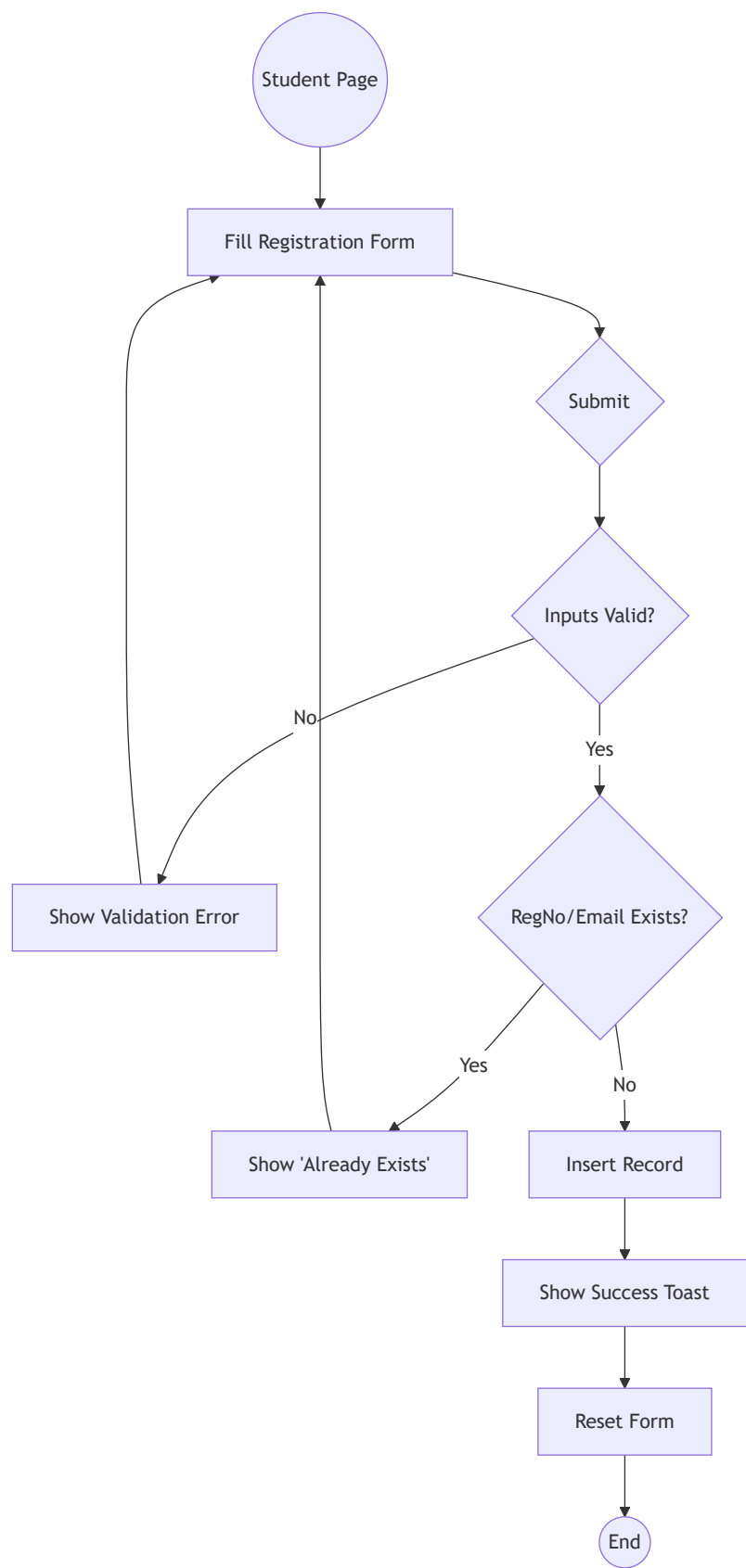
Reflects the flow of managing system assets and configuration.



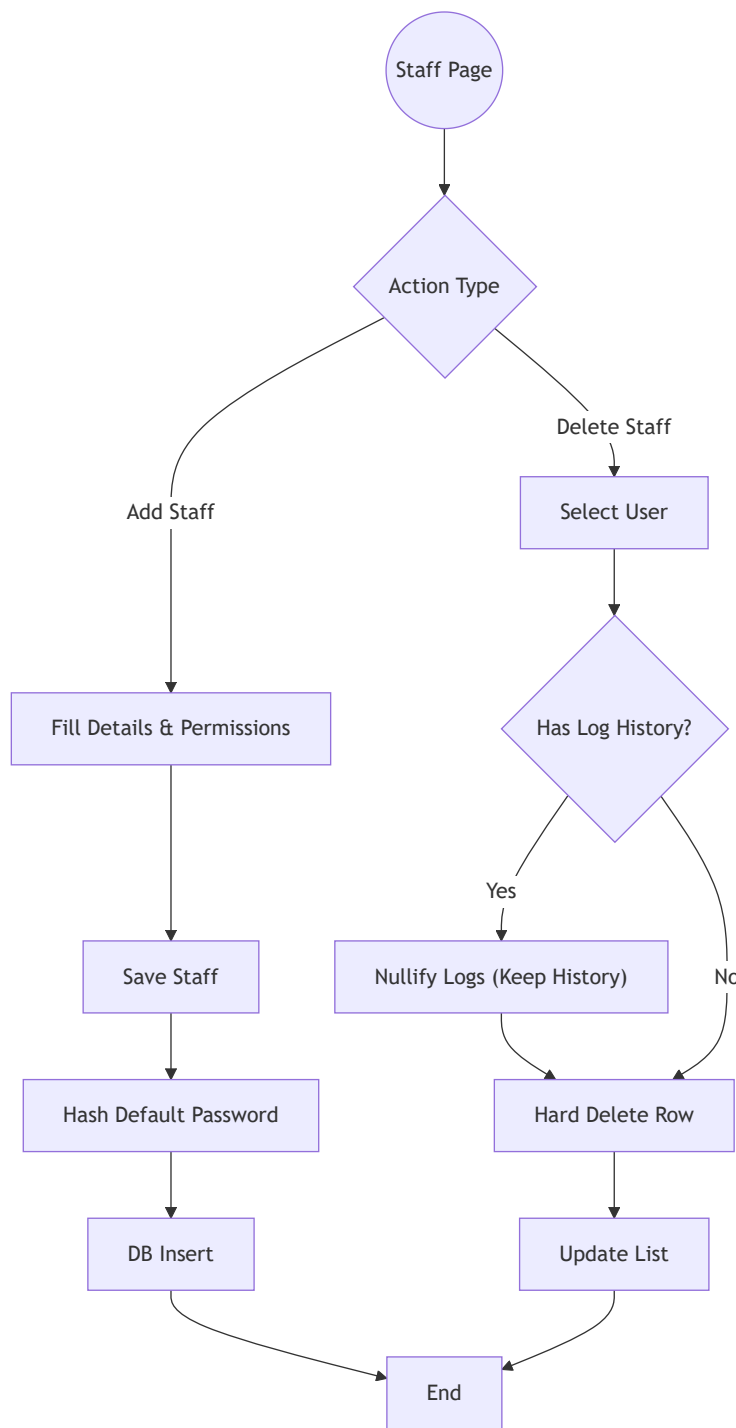
5.5.4 Authentication Activity (Login)



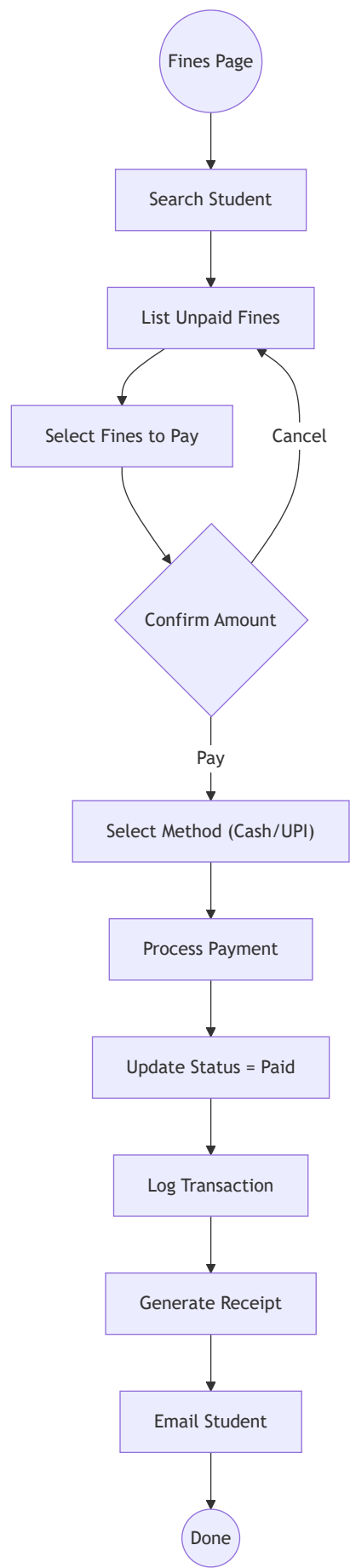
5.5.5 Student Registration Activity



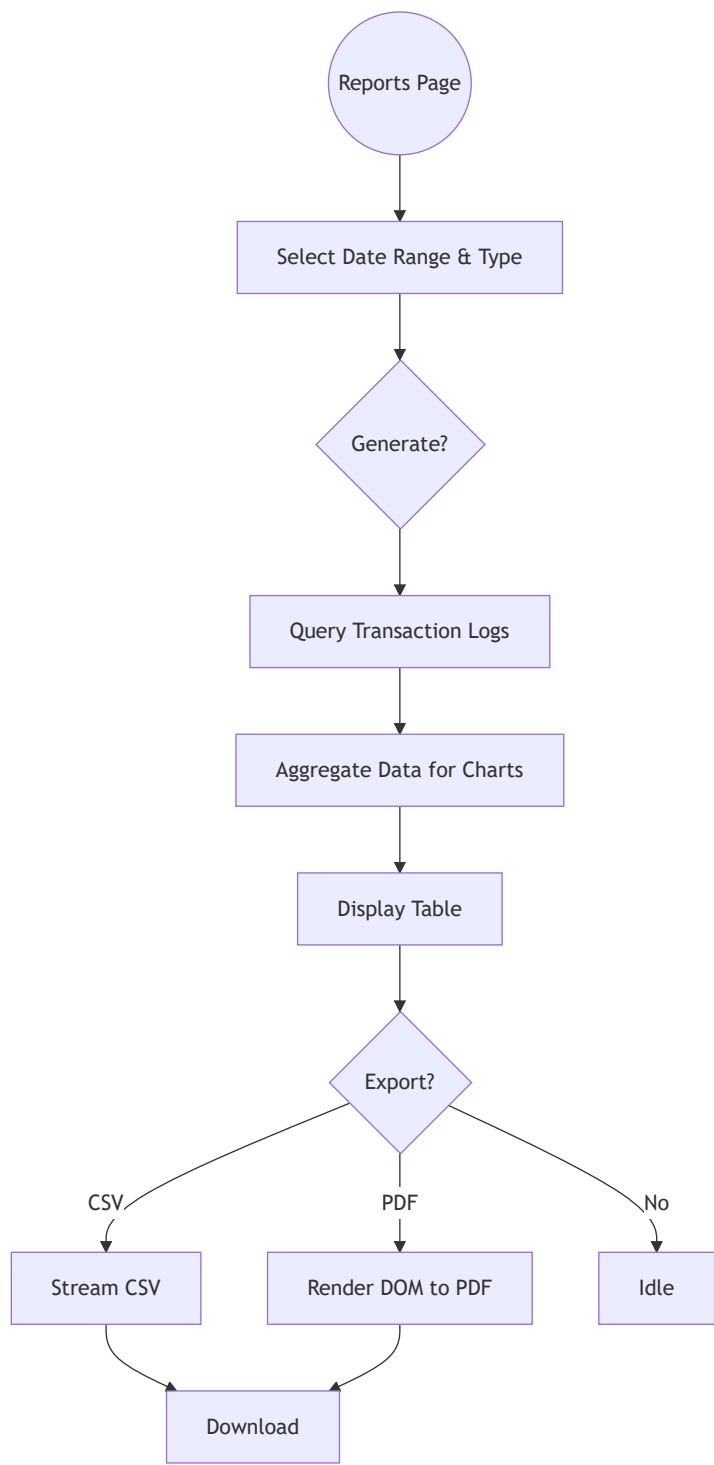
5.5.6 Staff Management Activity



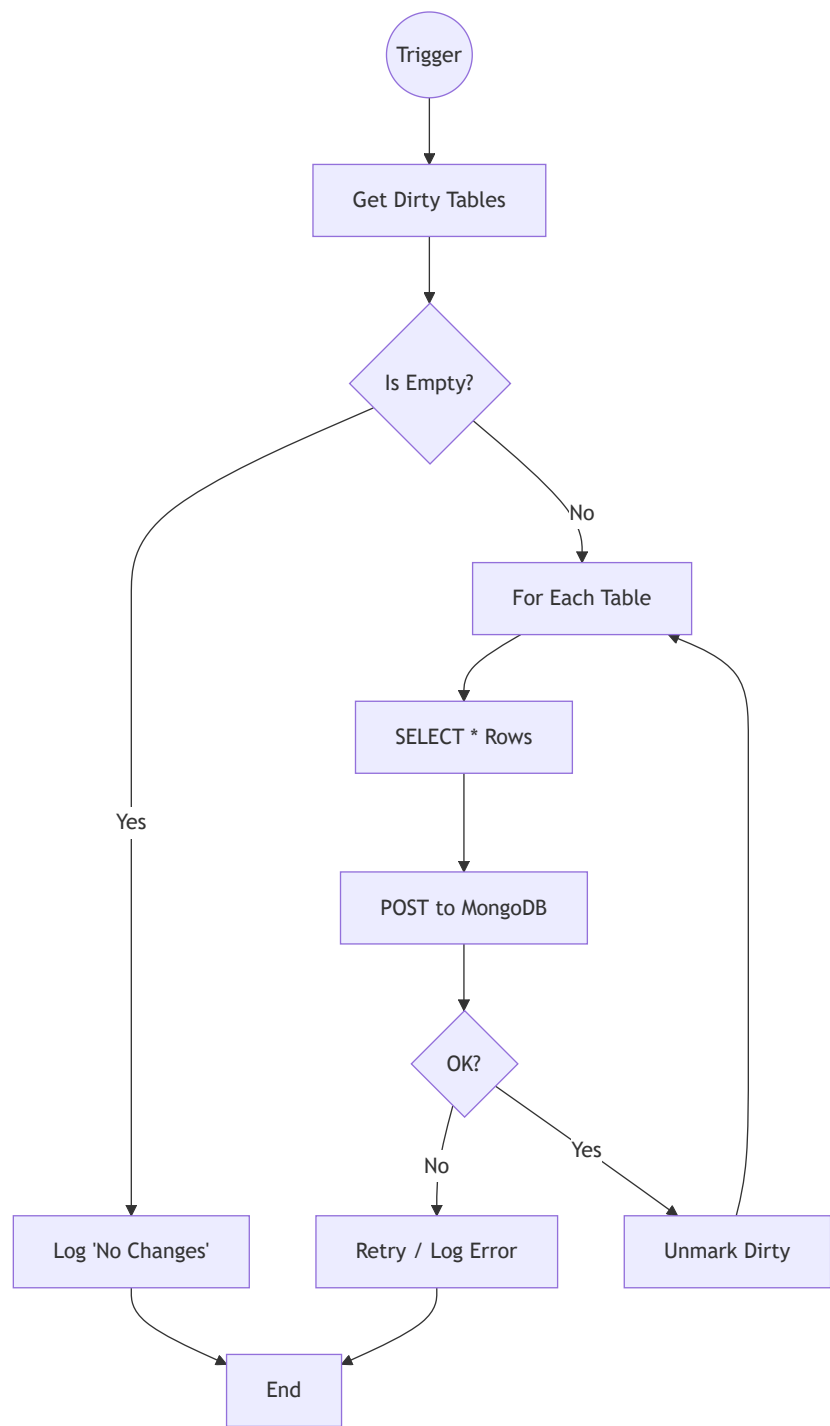
5.5.7 Fine Payment Activity



5.5.8 Report Generation Activity

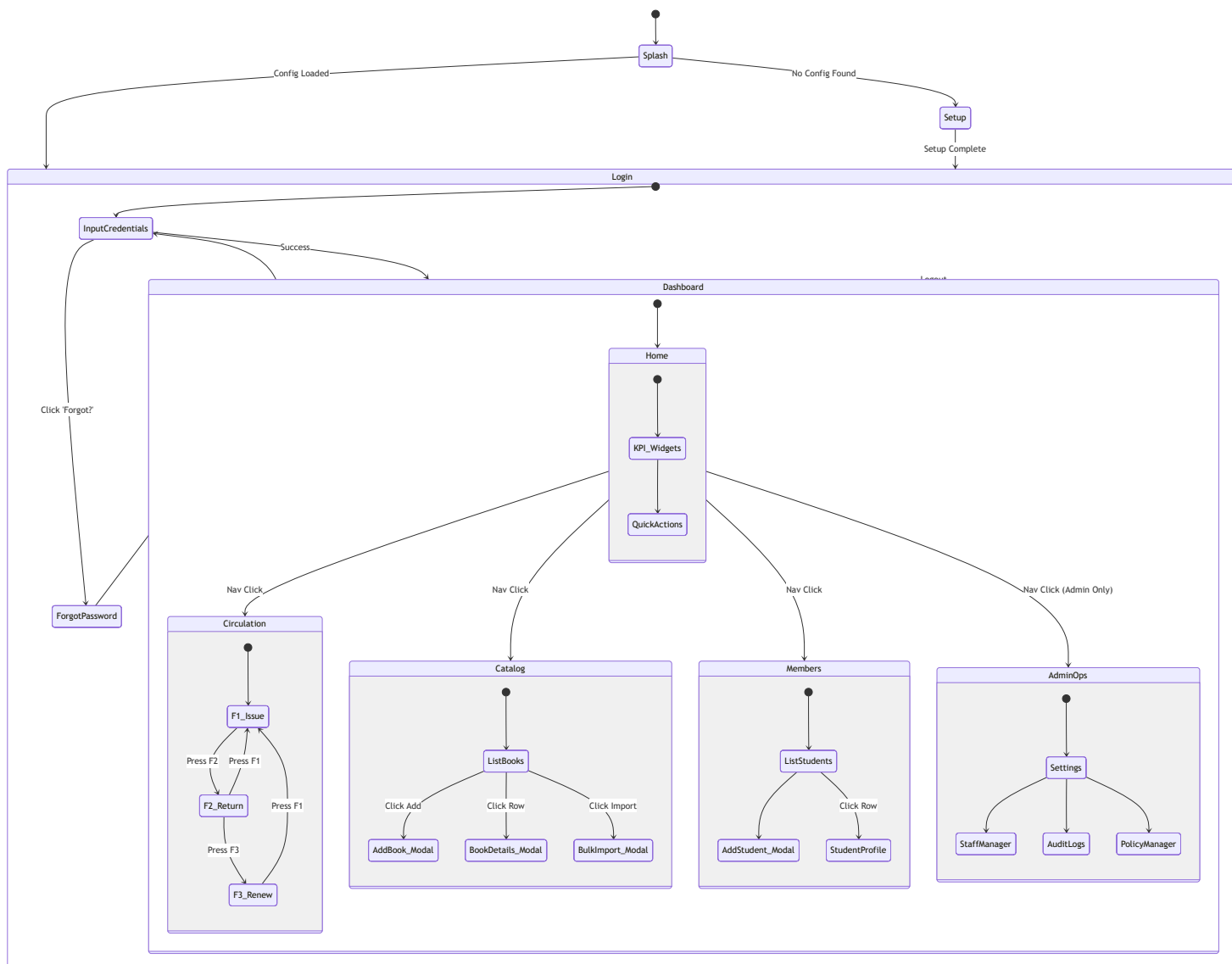


5.5.9 Cloud Sync Activity



5.6. UI Navigation Flow

This state diagram visualizes the screen transitions and user journey through the application.



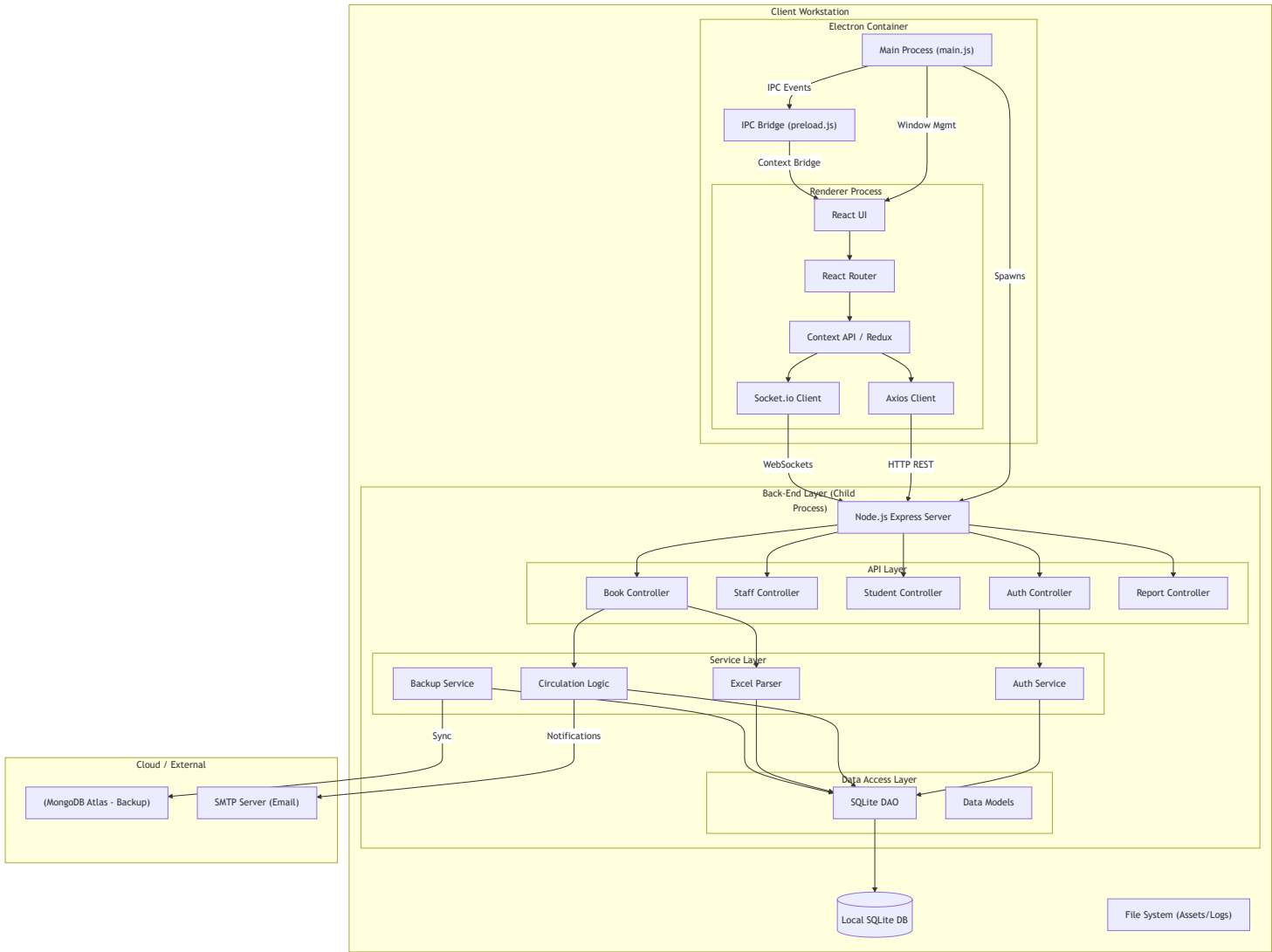
6. System Architecture (Technical Design)

The GPTK LMS is a **Desktop Application** built on a **Local-First, Hybrid Architecture**. It combines the performance of a native desktop app with the flexibility of modern web technologies.

6.1. Technology Stack

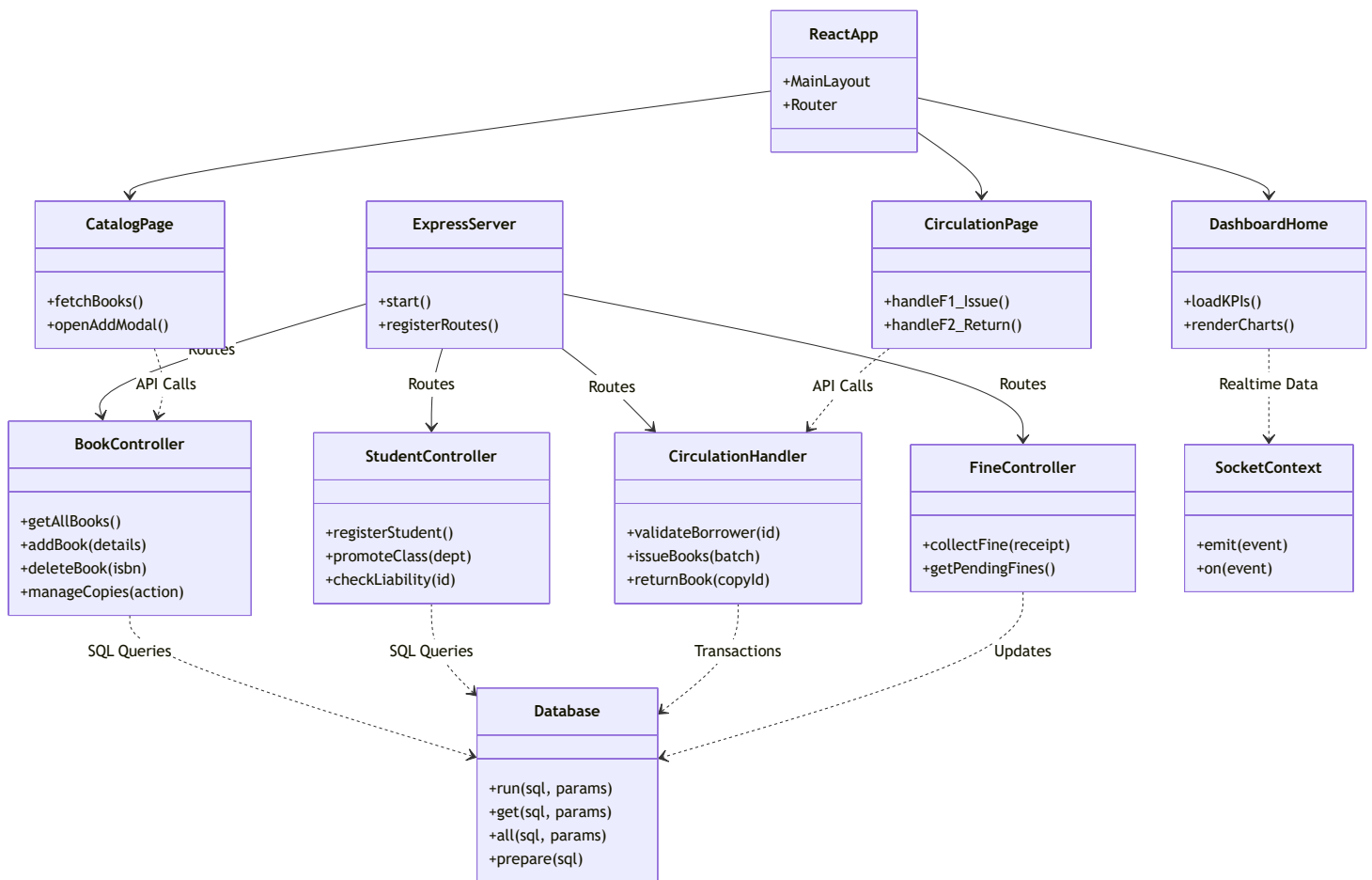
Component	Technology	Version	Purpose / Usage
Runtime	Electron	v40.0	Native desktop container, process management, and OS integration.
Frontend	React.js	v19	User Interface, Component state management (SPA).
Backend	Node.js + Express	Latest	REST API, Business Logic, and File System operations.
Database	SQLite3	v5.x	Serverless, local relational database for offline persistence.
Real-time	Socket.io	v4.x	Bi-directional event communication (Live Dashboards).
Styling	CSS / Styled Components	-	Responsive design and theming.
Build Tool	Vite / Webpack	-	Asset bundling and hot module replacement (HMR).

6.2. Architecture Diagram (Logical)



6.3. System Class Diagram (Code Structure)

This diagram represents the object-oriented structure of the application, mapping Frontend Components to Backend Controllers.



6.3. Key Architectural Features

- **Local-First Data:** All data is stored in `AppData/GPTK Library Manager/DB/lms.sqlite`. This ensures zero-latency operations and full offline capability.
- **Unified Process:** The Backend API (`server.js`) is launched programmatically by the Electron Main process (`main.js`) on app startup.
- **Frameless UI:** The application uses a custom title bar (min/max/close controls) implemented via Electron IPC (`ipcMain` / `ipcRenderer`).
- **Smart Backup:** A `changeDetection` service hooks into the Database layer to detect write operations (`INSERT` , `UPDATE` , `DELETE`) and mark the system as "dirty" to trigger backups or syncs.

7. Database Schema (SQLite)

The database matches a **Relational Model** with strict Key references.

7.0. Entity Relationship Diagram (ERD)

DEPARTMENTS			
string	id	PK	UUID
string	codeUK		e.g. CS
string	nameUK		Full Name
string	description		
string	hod_signature		Path
timestamp	created_at		
timestamp	updated_at		

ADMINS			
string	id	PK	UUID
string	name		
string	email	UK	
string	phone		
string	password_hash		
enum	status		
timestamp	last_login		
timestamp	created_at		
timestamp	updated_at		

BOOKS			
string	id	PK	UUID
string	isbn	UK	ISBN-13
string	title		
string	author		
string	publisher		
string	category		
string	dept_id	FK	-> departments.id
float	price		
int	stock_total		
int	total_copies		
string	shelf_location		
string	ebook_link		
string	cover_image		
enum	status		Active/Archived
timestamp	created_at		
timestamp	updated_at		

STUDENTS			
string	id	PK	UUID
string	register_number	UK	Roll No
string	full_name		
string	dept_id	FK	-> departments.id
string	semester		
string	email		
string	phone		
date	dob		
string	father_name		
string	address		
string	profile_image		
enum	status		Active/Blocked/Alumni
timestamp	created_at		
timestamp	updated_at		

BOOK_COPIES			
string	id	PK	UUID
string	accession_number	UK	Barcode
string	book_id	FK	-> books.id
string	book_isbn		
enum	status		Available/Issued/Lost
string	location		
timestamp	created_at		
timestamp	updated_at		

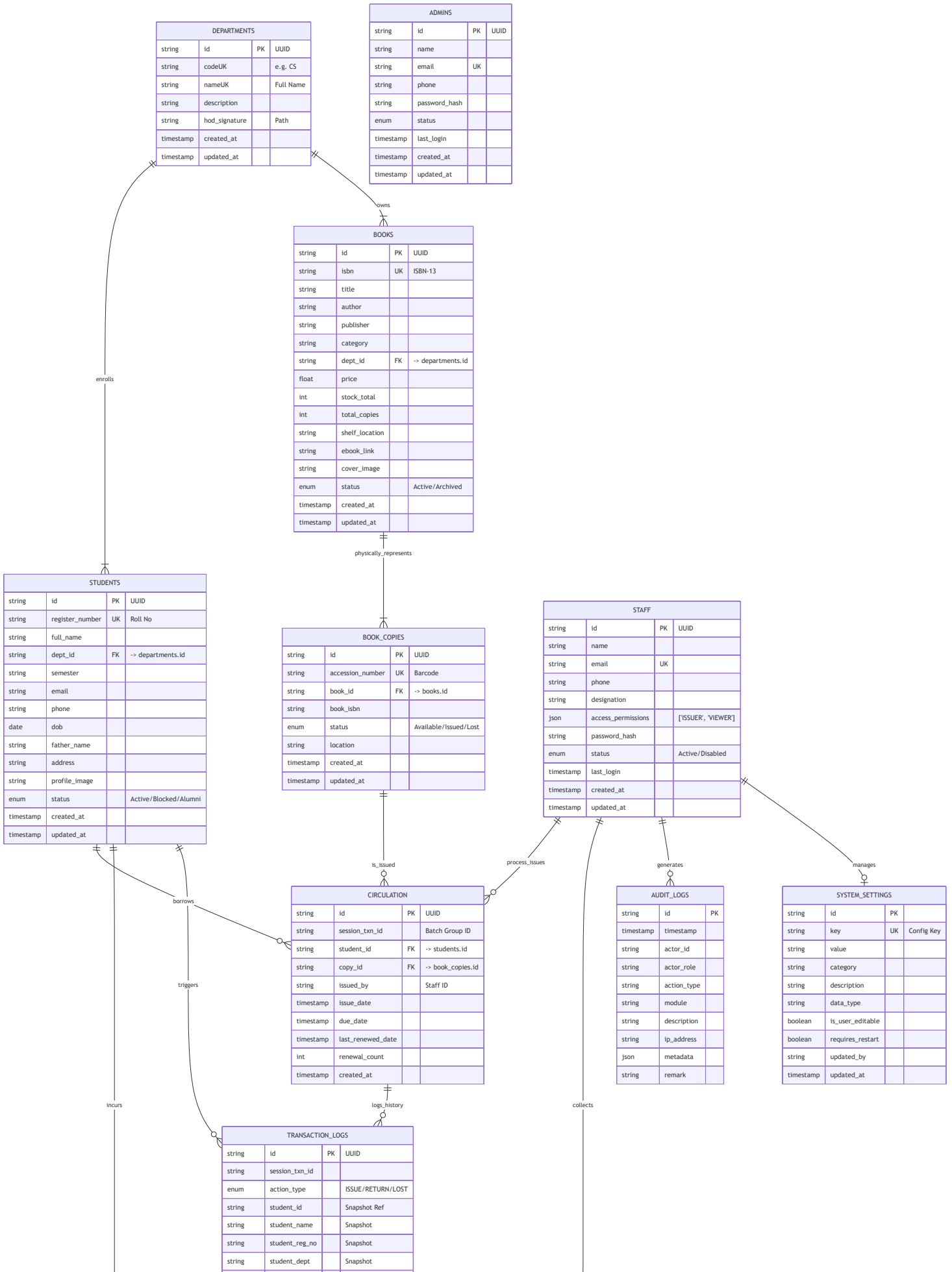
STAFF			
string	id	PK	UUID
string	name		
string	email	UK	
string	phone		
string	designation		
json	access_permissions		[ISSUER, VIEWER]
string	password_hash		
enum	status		Active/Disabled
timestamp	last_login		
timestamp	created_at		
timestamp	updated_at		

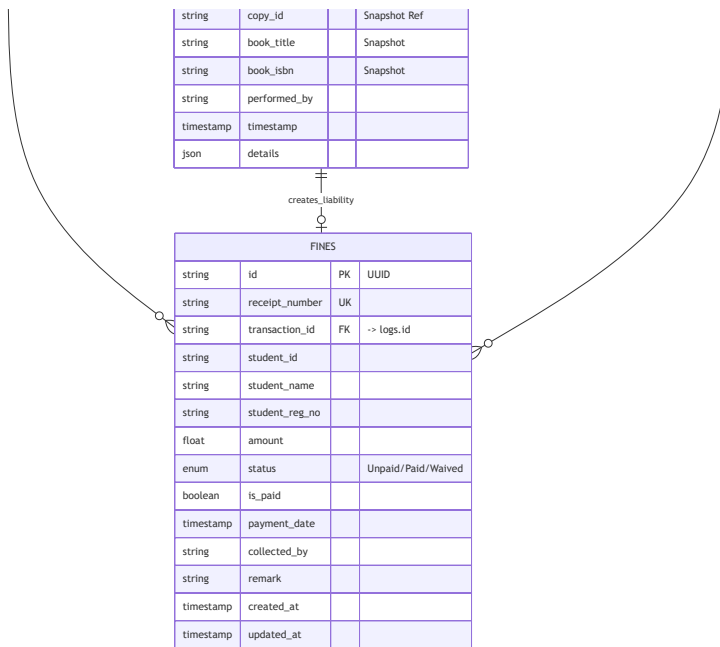
CIRCULATION			
string	id	PK	UUID
string	session_txn_id		Batch Group ID
string	student_id	FK	-> students.id
string	copy_id	FK	-> book_copies.id
string	issued_by		Staff ID
timestamp	issue_date		
timestamp	due_date		
timestamp	last_renewed_date		
int	renewal_count		
timestamp	created_at		

AUDIT_LOGS		
string	id	PK
timestamp	timestamp	
string	actor_id	
string	actor_role	
string	action_type	
string	module	
string	description	
string	ip_address	
json	metadata	
string	remark	

SYSTEM_SETTINGS			
string	id	PK	
string	key	UK	Config Key
string	value		
string	category		
string	description		
string	data_type		
boolean	is_user_editable		
boolean	requires_restart		
string	updated_by		
timestamp	updated_at		

TRANSACTION_LOGS			
string	id	PK	UUID
string	session_txn_id		
enum	action_type		ISSUE/RETURN/LOST
string	student_id		Snapshot Ref
string	student_name		Snapshot
string	student_reg_no		Snapshot
string	student_dept		Snapshot





7.1. Core Entities

departments (Academic Units)

Column	Type	Constraints	Description
id	TEXT	PRIMARY KEY	UUID v4
code	TEXT	UNIQUE	e.g., "CS", "CV"
name	TEXT	UNIQUE	Full Department Name
description	TEXT		Optional details
hod_signature	TEXT		Path to signature image
created_at	TEXT		ISO Timestamp
updated_at	TEXT		ISO Timestamp

students (Borrowers)

Column	Type	Constraints	Description
id	TEXT	PRIMARY KEY	UUID v4
register_number	TEXT	UNIQUE	College Roll No.
full_name	TEXT	NOT NULL	Student Name
dept_id	TEXT	FK -> departments.id	
semester	TEXT		Current Semester
email	TEXT	NOT NULL	Contact Email
phone	TEXT		Mobile Number
dob	TEXT	NOT NULL	Date of Birth
father_name	TEXT		Guardian Name
address	TEXT		Residential Address
profile_image	TEXT		Local file path
status	TEXT	ENUM	Active, Blocked, Alumni, Deleted

Column	Type	Constraints	Description
created_at	TEXT		ISO Timestamp
updated_at	TEXT		ISO Timestamp

staff (Librarians & Assistants)

Column	Type	Constraints	Description
id	TEXT	PRIMARY KEY	Staff ID / UUID
name	TEXT	NOT NULL	Staff Name
email	TEXT	UNIQUE	Login ID
phone	TEXT		Contact Number
designation	TEXT		Job Title
access_permissions	TEXT	JSON	Array e.g., ["ISSUER", "VIEWER"]
password_hash	TEXT	NOT NULL	Bcrypt Hash
status	TEXT	ENUM	Active, Disabled, Deleted
last_login	TEXT		Last Session Time
created_at	TEXT		ISO Timestamp
updated_at	TEXT		ISO Timestamp

admins (Superusers)

Column	Type	Constraints	Description
id	TEXT	PRIMARY KEY	UUID
name	TEXT	NOT NULL	Admin Name
email	TEXT	UNIQUE	Root Admin Email
phone	TEXT		Contact Number
password_hash	TEXT	NOT NULL	Bcrypt Hash
status	TEXT	ENUM	Active, Disabled
last_login	TEXT		Last Session Time
created_at	TEXT		ISO Timestamp
updated_at	TEXT		ISO Timestamp

books (Catalog Metadata)

Column	Type	Constraints	Description
id	TEXT	PRIMARY KEY	UUID
isbn	TEXT	UNIQUE	Identifier (ISBN-13)
title	TEXT	NOT NULL	Book Title
author	TEXT	NOT NULL	Author Name
publisher	TEXT		Publisher Name
category	TEXT		e.g., "Reference", "Lending"
dept_id	TEXT	FK -> departments.id	Owner Department

Column	Type	Constraints	Description
price	REAL		Asset Value
stock_total	INTEGER	DEFAULT 0	Computed Total
total_copies	INTEGER	DEFAULT 0	Computed Copies
shelf_location	TEXT		Location Code
ebook_link	TEXT		URL/Path to PDF
cover_image	TEXT		Path to cover file
cover_image_url	TEXT		Legacy Support
status	TEXT	ENUM	Active, Deleted, Archived
created_at	TEXT		ISO Timestamp
updated_at	TEXT		ISO Timestamp

book_copies (Physical Inventory)

Column	Type	Constraints	Description
id	TEXT	PRIMARY KEY	UUID
accession_number	TEXT	UNIQUE	Barcode Label ID
book_id	TEXT	FK -> books.id	Reference to Master Record
book_isbn	TEXT	FK -> books.isbn	Redundant Link for Search
status	TEXT	ENUM	Available, Issued, Lost, Maintenance
location	TEXT		Dynamic Location (if diff from master)
created_at	TEXT		ISO Timestamp
updated_at	TEXT		ISO Timestamp

7.2. Circulation & Finance

circulation (Active Loans)

Tracks books currently out of the library.

Column	Type	Constraints	Description
id	TEXT	PRIMARY KEY	UUID
session_txn_id	TEXT		Group ID for Batch Issues
student_id	TEXT	FK -> students.id	Borrower
copy_id	TEXT	FK -> book_copies.id	Specific Copy
issued_by	TEXT		Staff ID
issue_date	TEXT		ISO Timestamp
due_date	TEXT		ISO Timestamp
last_renewed_date	TEXT		Date of last extension
renewal_count	INTEGER	DEFAULT 0	Count of extensions
created_at	TEXT		ISO Timestamp

transaction_logs (History)

Decoupled history. Stores SNAPSHOTS of data.

Column	Type	Constraints	Description
id	TEXT	PRIMARY KEY	UUID
session_txn_id	TEXT		Link to Original Session
action_type	TEXT		ISSUE, RETURN, RENEW, LOST
student_id	TEXT		Reference ID (Nullable)
student_name	TEXT	SNAPSHOT	Name at time of txn
student_reg_no	TEXT	SNAPSHOT	Roll No at time of txn
student_dept	TEXT	SNAPSHOT	Dept at time of txn
copy_id	TEXT		Reference ID (Nullable)
book_title	TEXT	SNAPSHOT	Title at time of txn
book_isbn	TEXT	SNAPSHOT	ISBN at time of txn
performed_by	TEXT		Staff ID who acted
timestamp	TEXT		Log Date
details	TEXT	JSON	Remarks, Metadata

fines (Financial Records)

Column	Type	Constraints	Description
id	TEXT	PRIMARY KEY	UUID
receipt_number	TEXT	UNIQUE	Auto-Generated ID
transaction_id	TEXT	FK -> logs.id	Link to Loan Event
student_id	TEXT		Reference ID
student_name	TEXT	SNAPSHOT	Name for Receipt
student_reg_no	TEXT	SNAPSHOT	Roll No for Receipt
amount	REAL		Fine Amount
status	TEXT	ENUM	Unpaid, Paid, Waived
is_paid	INTEGER	BOOL	1 = Paid
payment_date	TEXT		Date of Collection
collected_by	TEXT		Staff ID
remark	TEXT		Waiver/Payment Note
created_at	TEXT		ISO Timestamp
updated_at	TEXT		ISO Timestamp

7.3. System configuration

system_settings

Column	Type	Constraints	Description
id	TEXT	PRIMARY KEY	UUID

Column	Type	Constraints	Description
key	TEXT	UNIQUE	Config Key (e.g., <code>circ.fine</code>)
value	TEXT		Config Value
category	TEXT		Grouping
description	TEXT		Help Text
data_type	TEXT		string, json, number
is_user_editable	INTEGER	DEFAULT 1	0 = System Protected
requires_restart	INTEGER	BOOL	1 if restart needed
updated_by	TEXT		Staff ID
updated_at	TEXT		ISO Timestamp

broadcast_logs (Communication)

Column	Type	Constraints	Description
id	TEXT	PRIMARY KEY	UUID
sender_id	TEXT		Staff who sent it
sent_at	TEXT		ISO Timestamp
subject	TEXT		Message Title
message_body	TEXT		Content
target_group	TEXT		Students / Staff / Dept
recipient_count	INTEGER		Count of targets
status	TEXT	ENUM	Sent / Failed

password_resets (Security)

Column	Type	Constraints	Description
email	TEXT	PRIMARY KEY	User Email
otp	TEXT	NOT NULL	One Time Password
expires_at	TEXT	NOT NULL	Expiry Timestamp
created_at	TEXT		ISO Timestamp

email_config (SMTP)

Column	Type	Constraints	Description
id	TEXT	PRIMARY KEY	UUID
service_status	INTEGER	BOOL	1 = Enabled
provider	TEXT		Gmail / SendGrid / Custom
smtp_host	TEXT		Server Address
smtp_port	INTEGER		Port (465/587)
smtp_secure	INTEGER	BOOL	SSL/TLS
smtp_user	TEXT		Username
smtp_pass	TEXT		Password/App Key

Column	Type	Constraints	Description
cloud_api_key	TEXT		For API Providers
cloud_region	TEXT		Region Code
from_email	TEXT		Sender Address
from_name	TEXT		Sender Name
triggers	TEXT	JSON	Enabled Alerts
updated_at	TEXT		ISO Timestamp

policy_config (Rules Engine)

Column	Type	Constraints	Description
id	TEXT	PRIMARY KEY	UUID
policy_version	INTEGER		Version Number
active_from	TEXT		Date Rule is active
profiles	TEXT	JSON	Borrower Limits (Student/Staff)
financials	TEXT	JSON	Fine Rates & Penalties
holidays	TEXT	JSON	Calendar Config
security	TEXT	JSON	Security Settings
updated_at	TEXT		ISO Timestamp

audit_logs

Column	Type	Constraints	Description
id	TEXT	PRIMARY KEY	UUID
timestamp	TEXT	DEFAULT NOW	ISO Timestamp
actor_id	TEXT		User ID
actor_role	TEXT		Admin / Staff
action_type	TEXT		LOGIN, CREATE, DELETE
module	TEXT		Affected Area
description	TEXT		Human Readable Log
ip_address	TEXT		Client IP
metadata	TEXT	JSON	Diff of changes
remark	TEXT		Optional Note

sync_queue (Cloud Sync)

Column	Type	Constraints	Description
table_name	TEXT		Table modified
record_id	TEXT		Row affected
operation	TEXT		INSERT / UPDATE / DELETE
status	TEXT	ENUM	pending, synced, failed

- **No .env files:** All runtime config is stored here and editable by Admins.

9. API Reference Specification

The backend exposes a RESTful API running on localhost:PORT (default 5000).

Base URL: http://localhost:5000/api

Auth Header: Authorization: Bearer <jwt_token>

9.1. Auth & Session Management

Method	Endpoint	Access	Description	Request Body / Query
POST	/auth/login	Public	Authenticate user (Staff/Admin)	{ "email": "...", "password": "..." }
POST	/auth/forgot-password	Public	Send OTP for reset	{ "email": "..." }
POST	/auth/verify-otp	Public	Verify Reset OTP	{ "email": "...", "otp": "..." }
POST	/auth/reset-password	Public	Set new password	{ "email": "...", "otp": "...", "newPassword": "..." }
POST	/auth/change-password	User	Change current user pass	{ "oldPassword": "...", "newPassword": "..." }

9.2. Book Catalog Module

Method	Endpoint	Access	Description	Request Body / Query
GET	/books	Public	List & Search Books	?q=search&page=1&limit=20
GET	/books/:isbn	Public	Get Book Details (Master)	-
POST	/books	Staff	Create New Book	{ "isbn": "...", "title": "...", "author": "...", "category": "...", "price": 0
PUT	/books/:isbn	Staff	Update Book Metadata	{ "title": "...", "shelf_location": "...", "status": "Active" }
DELETE	/books/:isbn	Admin	Delete Book Master	-
POST	/books/:isbn/add-copies	Staff	Add Physical Copies	{ "count": 5 }
PUT	/books/copy/:id	Staff	Update Copy Status	{ "status": "Lost/Maintenance" }
DELETE	/books/copy/:id	Admin	Remove Specific Copy	-
POST	/books/bulk	Admin	Bulk Upload CSV/Excel	FormData: { "file": <binary> }

9.3. Student & Borrower Management

Method	Endpoint	Access	Description	Request Body / Query
GET	/students	Staff	List Students	?dept=CS&status=Active&page=1

Method	Endpoint	Access	Description	Request Body / Query
GET	/students/defaulters	Staff	List Overdue Users	?days_overdue=7
GET	/students/:id	Staff	Get Student Profile	-
POST	/students	Staff	Register Student	{ "register_number": "...", "name": "...", "dept_id": "...", "email": "..." }
PUT	/students/:id	Staff	Update Profile	{ "phone": "...", "address": "..." }
DELETE	/students/:id	Admin	Delete Account	-
POST	/students/promote	Admin	Batch Promote Sem	{ "dept": "CS", "from_sem": "3", "to_sem": "5" }
POST	/students/promotion-scan	Admin	Scan for Promote	{ "dept": "CS" }
POST	/students/bulk-import	Admin	Import Students	FormData: { "file": <binary> }
POST	/students/bulk-delete	Admin	Delete Multiple	{ "ids": ["uuid1", "uuid2"] }
POST	/students/export	Staff	Export List to Excel	?format=xlsx
POST	/students/photo/upload	Staff	Upload Profile Pic	FormData: { "id": "...", "photo": <binary> }
GET	/students/photo/stats	Staff	Photo Compliance	-

9.4. Circulation (Issue / Return)

Method	Endpoint	Access	Description	Request Body / Query
GET	/circulation/validate-borrower/:id	Staff	Check Eligibility	-
POST	/circulation/issue	Staff	Issue Book	{ "student_id": "...", "copy_id": "..." }
POST	/circulation/return	Staff	Return Book	{ "copy_id": "..." }
POST	/circulation/renew	Staff	Renew Loan	{ "loan_id": "..." }
GET	/circulation/history	Staff	Transaction Logs	?start_date=...&end_date=...
GET	/circulation/loans/:studentId	Staff	Active Loans (User)	-
GET	/circulation/holders/:isbn	Staff	Who has this book?	-
GET	/circulation/next-accession/:isbn	Staff	Suggest Barcode	-
GET	/circulation/policy-defaults	Staff	Get Return Rules	-
POST	/circulation/resolve-scan	Staff	Identify Barcode	{ "barcode": "..." }

9.5. Financials & Fine Management

Method	Endpoint	Access	Description	Request Body / Query
GET	/fines	Staff	Global Fine Search	?status=Unpaid
GET	/fines/student/:studentId	Staff	User Fines	-
GET	/fines/receipt/:receiptId	Staff	Get Receipt ID	-
POST	/fines/collect	Staff	Collect Payment	{ "fine_ids": ["..."], "amount": 100, "mode": "Cash" }
POST	/fines/waive	Admin	Waive Fine	{ "fine_id": "...", "reason": "Medical" }
POST	/fines/update	Admin	Correct Amount	{ "fine_id": "...", "new_amount": 50 }
POST	/fines/resend-receipt	Staff	Email Receipt	{ "receipt_number": "..." }

9.6. System Configuration & Settings

Method	Endpoint	Access	Description	Request Body / Query
GET	/settings/app	Admin	Get All Configs	-
PUT	/settings/app	Admin	Update Config	{ "settings": [{ "key": "circ.limit", "value": 3 }] }
POST	/settings/change-password	Admin	Force Pass Change	{ "userId": "...", "newPass": "..." }
POST	/settings/factory-reset	Root	Wipe Database	{ "confirm": true, "password": "..." }
POST	/settings/backup/create	Admin	Trigger Local Backup	-
POST	/settings/cloud/backup	Admin	Push to Cloud	-
POST	/settings/cloud/restore	Admin	Pull from Cloud	-
POST	/settings/test-email	Admin	Validate SMTP	{ "to": "..." }
GET	/settings/principal-signature	Admin	Get HOD Sig	-

9.7. Administrative Operations

Method	Endpoint	Access	Description	Request Body / Query
GET	/admin	Root	List Admins	-
POST	/admin	Root	Create Admin	{ "name": "...", "email": "...", "password": "..." }
POST	/admin/broadcast	Admin	Send System Msg	{ "target": "students", "message": "..." }
GET	/admin/broadcast/history	Admin	View Sent Msgs	-
GET	/audit	Admin	View Audit Logs	?module=AUTH
GET	/audit/stats	Admin	Log Statistics	-
GET	/health	Public	Ping Backend	-
GET	/health/connectivity	Public	Check Internet	-

9.8. Policy & Departments

Method	Endpoint	Access	Description	Request Body / Query
GET	/policy	Public	Get Rules	-
PUT	/policy	Admin	Update Rules	{ "student_limit": 5, "fine_per_day": 10 }
GET	/departments	Public	List Departments	-

Method	Endpoint	Access	Description	Request Body / Query
POST	/departments	Admin	Add Department	{ "code": "CS", "name": "Computer Sci" }
DELETE	/departments/:id	Admin	Remove Dept	-

9.9. Analytics & Reporting

Method	Endpoint	Access	Description	Request Body / Query
GET	/dashboard/stats	Staff	KPI Cards	-
GET	/dashboard/charts	Staff	Graph Data	-
GET	/reports/circulation	Admin	Issue/Return Rpt	?start=...&end=...
GET	/reports/financial	Admin	Revenue Rpt	?start=...&end=...
GET	/reports/inventory	Admin	Stock Rpt	-

10. Electron Main Process Details

File: electron/main.js

- 1. **Backend Injection:**
 - Starts the Express server (backend/server.js) as a direct dependency.
 - Injects USER_DATA_PATH so the backend knows where to find the database file, ensuring portability.
- 2. **Window Management:**
 - Creates a 1200x800 (default) frameless window.
 - Restores previous window state (maximized, position) from window-state.json .
- 3. **IPC Channels:**
 - window-minimize , window-maximize , window-close : Handle custom title bar actions.
 - shutdown : Listens for backend signals to close the app gracefully.

11. Security Implementation

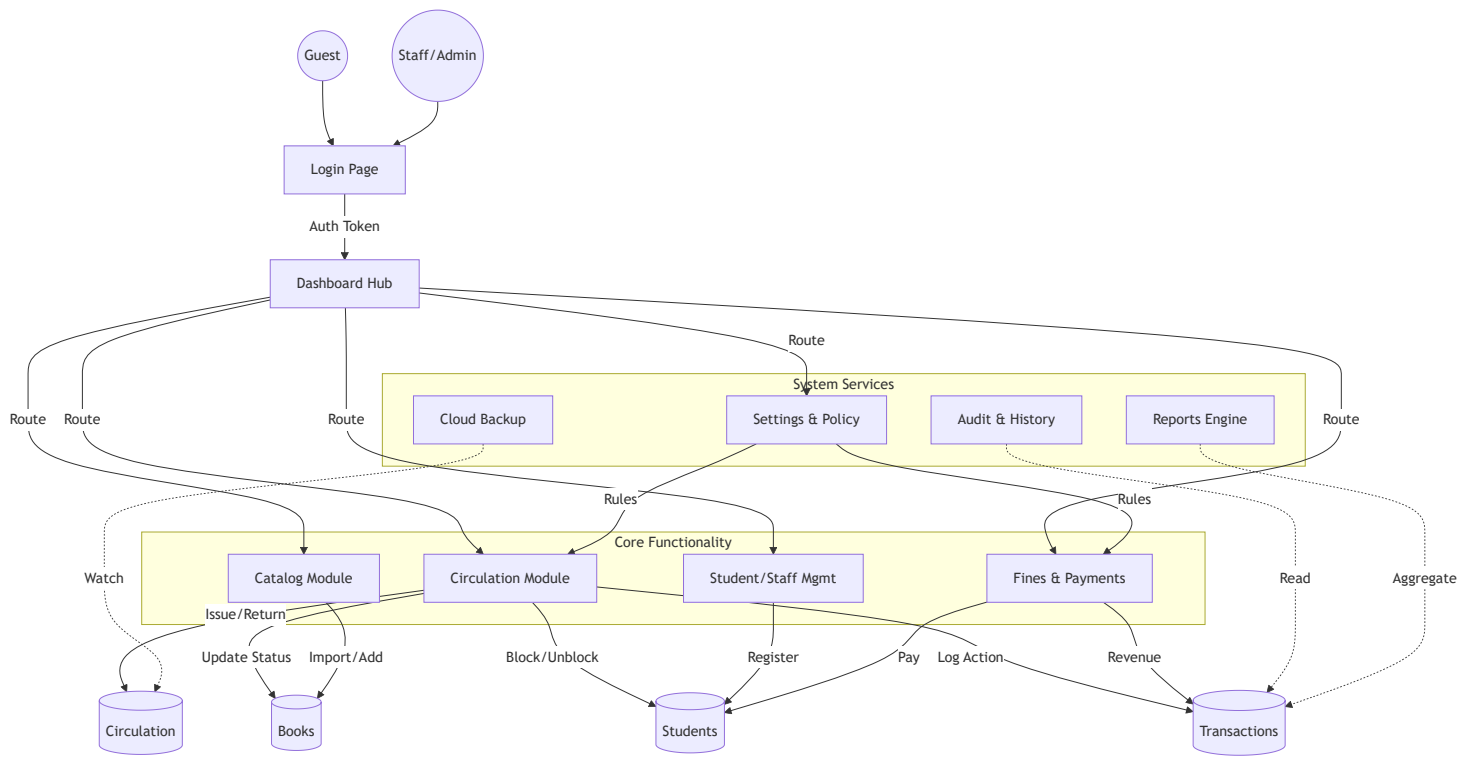
- 1. **Authentication:**
 - JWT (JSON Web Token) based stateless auth.
 - Tokens are stored in the client and sent via Authorization: Bearer headers.
- 2. **Role-Based Access Control (RBAC):**
 - Admins:** Full access to Settings, Policy, and Staff Management.
 - Staff:** Access determined by access_permissions JSON in DB (e.g., can issue books but not delete them).
- 3. **Data Safety:**
 - requires_restart flag in system_settings ensures critical config changes (like Port or DB Path) are applied safely.
 - Automated "Smart Backups" isolate data before risky operations.

12. Logic Flow & Data Maps (Detailed)

This section details the technical lifecycle of data, including exact **JSON Payloads**, **Database Operations**, and **Visual Diagrams**.

11.0. Grand Unified Data Flow (System Logic Map)

This diagram illustrates how all functional modules interconnect and impact the shared database state.



11.1. Authentication Flow (Login Page)

Route: /login

1. **Request** (POST /api/auth/login):

```
{
  "email": "veerkotresh@gmail.com",
  "password": "password123" // Plaintext
}
```

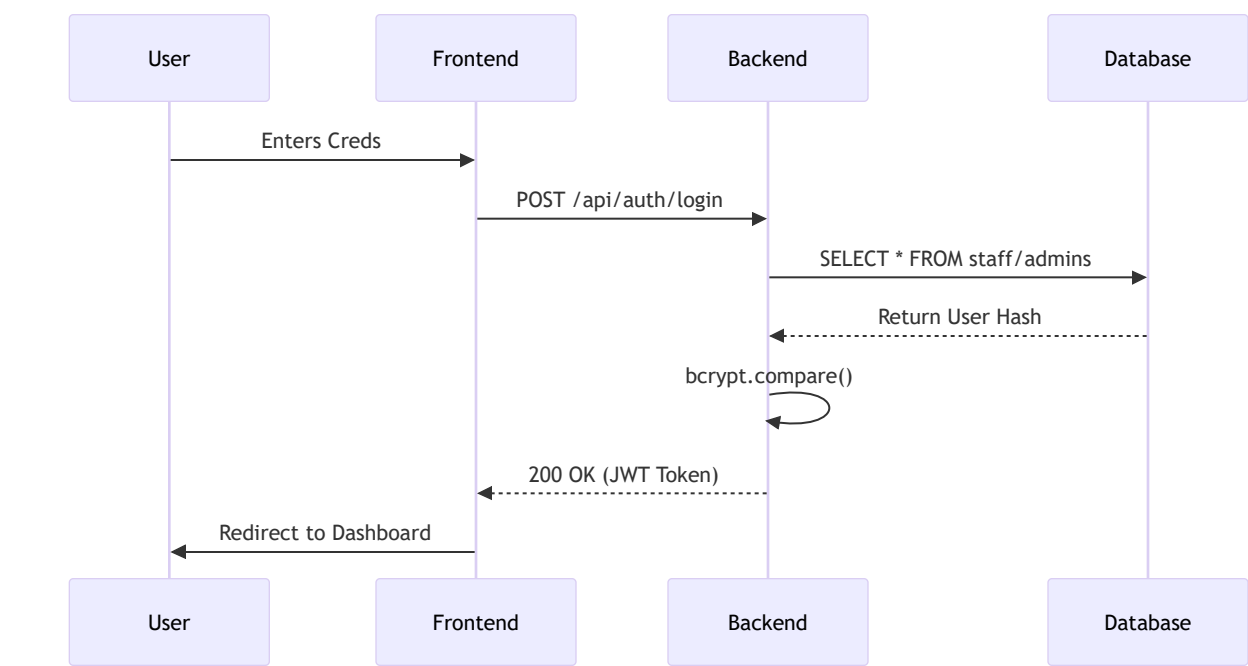
2. **Backend Logic** (authController.js):

- **Query:** SELECT * FROM admins WHERE email = ? (Falls back to staff if not found).
- **Crypto:** bcrypt.compare(password, user.password_hash) .
- **Status Check:** Rejects if status === 'Disabled' .

3. **Response** (200 OK):

```
{
  "token": "eyJhbGciOiJIUzI1...", // JWT (Payload: { id, role, email })
  "user": {
    "id": "admin-seed-123",
    "name": "System Admin",
    "email": "veerkotresh@gmail.com",
    "role": "admin"
  }
}
```

Visual Flow (Login)



11.2. Circulation: Issue Transaction

Route: /dashboard/circulation (F1 Tab)

- 1. **Validation Request** (GET /api/circulation/validate-borrower/:id):
 - Backend: Calculates unpaid_fines + (overdue_books * daily_rate) .
 - Response:

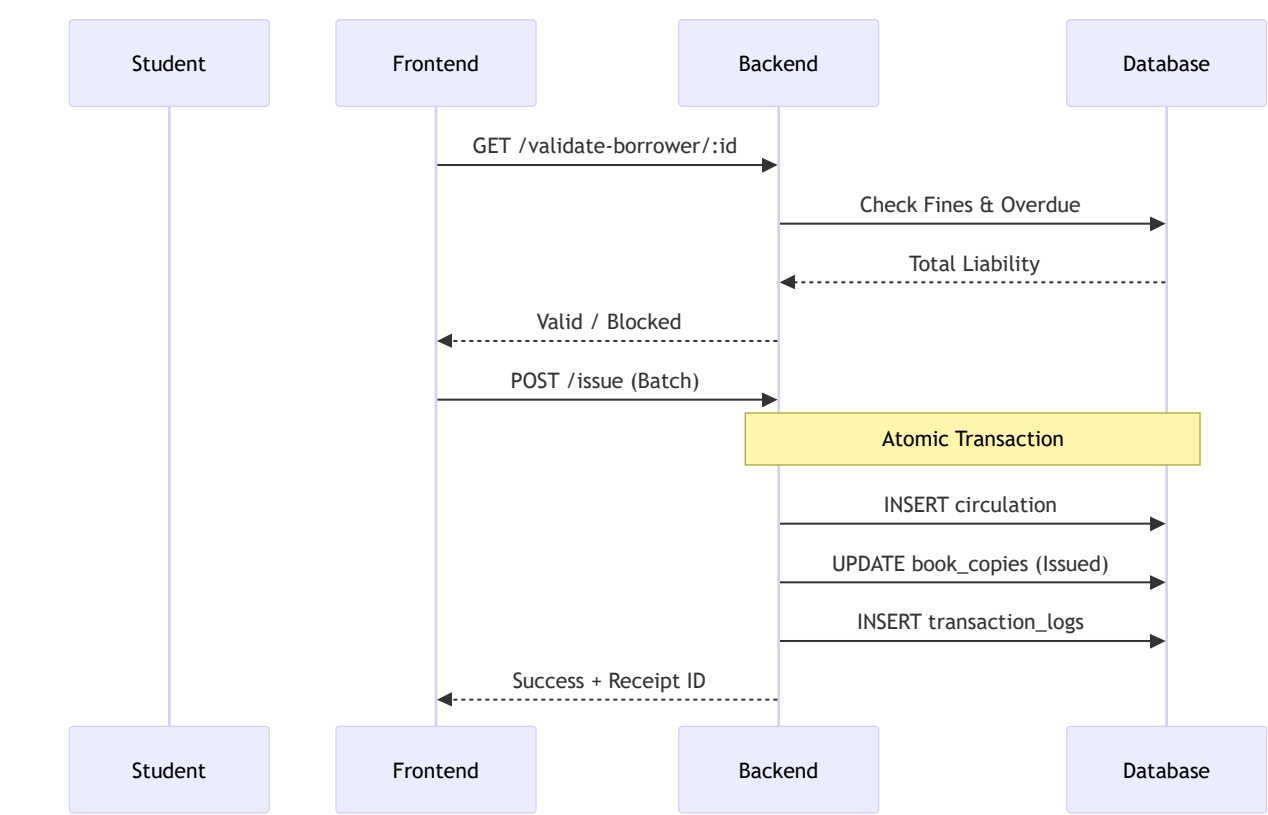
```
{
  "valid": true, // or false
  "liability": 450.00,
  "limit": 500.00,
  "alert_msg": null
}
```

- 2. **Commit Issue** (POST /api/circulation/issue):

```
{
  "student_id": "uuid-student-001",
  "books": [
    { "copy_id": "uuid-copy-A", "isbn": "978-3-16", "accession": "978-001" },
    { "copy_id": "uuid-copy-B", "isbn": "978-1-44", "accession": "978-002" }
  ]
}
```

- 3. **Backend Transaction:**
 - Batch Insert: Creates circulation rows for each book.
 - Update: Sets book_copies.status = 'Issued' .
 - Audit: Inserts transaction_logs with action_type: 'ISSUE' .

Visual Flow (Issue)



11.3. Circulation: Return & Fines

Route: /dashboard/circulation (F2 Tab)

1. Return Request (POST /api/circulation/return):

```
{
  "loan_id": "uuid-loan-123",
  "return_date": "2026-01-28", // ISO Date
  "condition": "Damaged", // Good / Damaged / Lost
  "remarks": "Cover torn"
}
```

2. Logic:

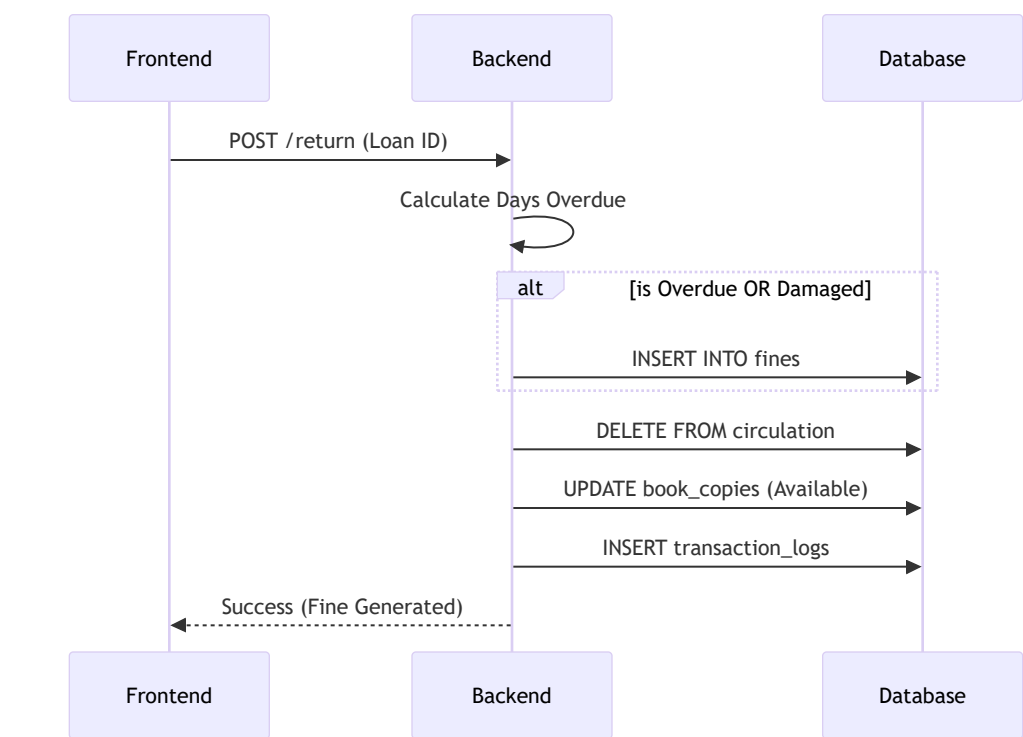
- **Overdue Calc:** DateDiff(return_date, due_date) * fine_per_day .
- **Damage Calc:** Reads policy_financial.damagedFineAmount (e.g., â,100).

3. Data Persistence:

- **Delete:** Removes row from circulation .
- **Insert Fine:**

```
INSERT INTO fines (amount, status, type) VALUES (150.0, 'Unpaid', 'DAMAGE_OVERDUE');
```

Visual Flow (Return)



12.4. Catalog: Add New Book

Route: /dashboard/books -> "Add Book"

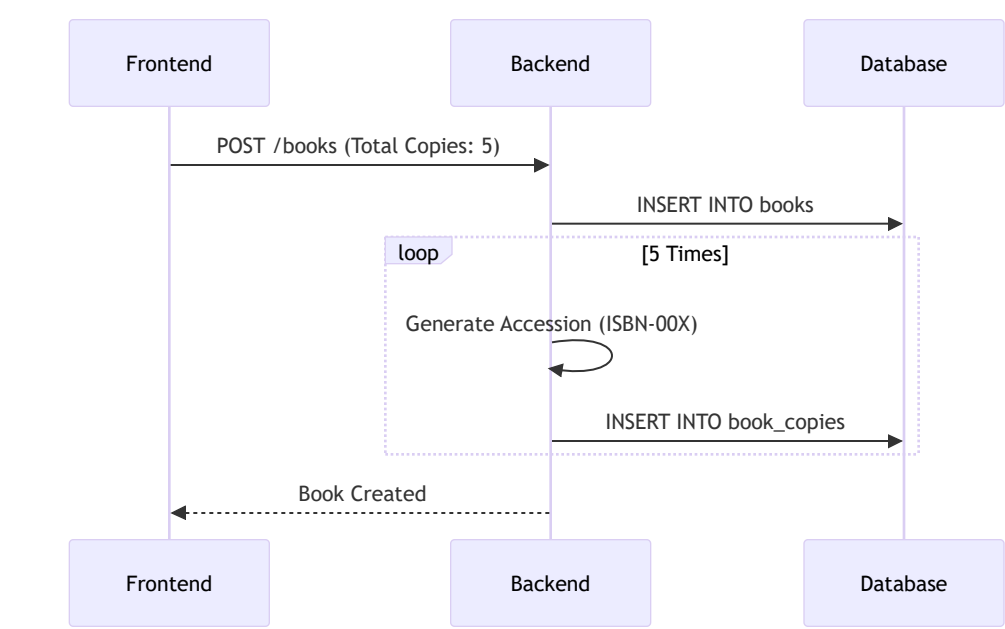
1. Payload (POST /api/books):

```
{
  "isbn": "9781234567890",
  "title": "Clean Code",
  "author": "Robert C. Martin",
  "dept_id": "uuid-dept-cs", // or "Computer Science" (Legacy fallback)
  "category": "Reference",
  "price": 4500.00,
  "total_copies": 5, // Auto-generates 5 physical copies
  "shelf_location": "R1-S2"
}
```

2. Backend Lifecycle:

- **Master:** Inserts into books table.
- **Inventory:** Generates 5 book_copies rows with auto-incremented accession_number (e.g., 978123-001 to 005).

Visual Flow (Add Book)



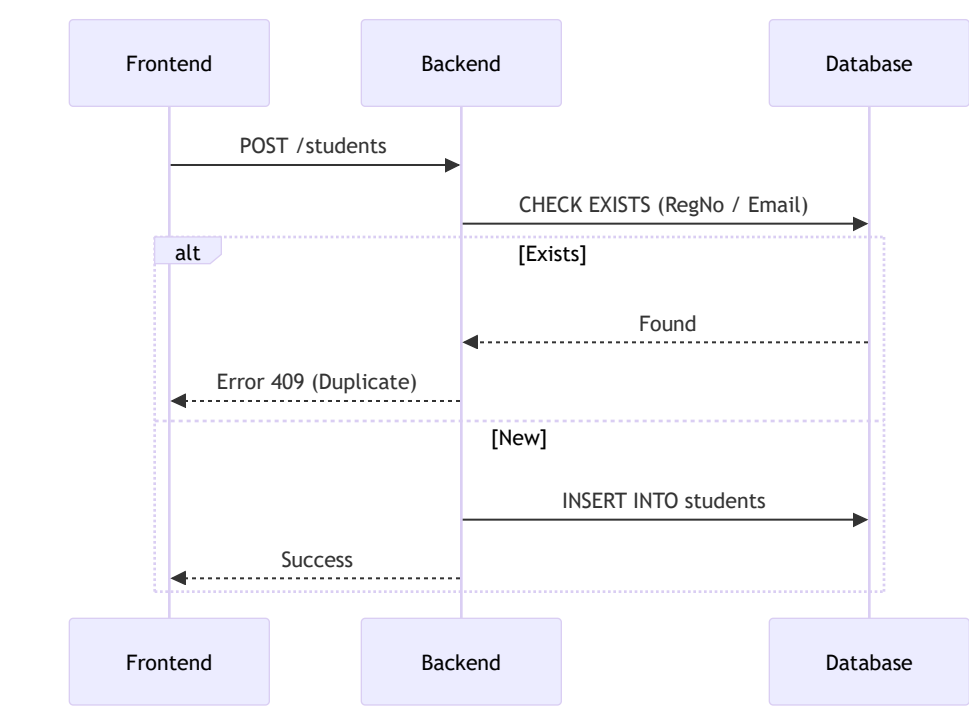
12.5. Students: Registration

Route: /dashboard/students

1. Payload (POST /api/students):

```
{
  "full_name": "John Doe",
  "register_number": "USN-001", // UNIQUE check
  "dept_id": "uuid-dept-civil",
  "semester": "3",
  "email": "john@college.edu",
  "phone": "9876543210",
  "dob": "2005-08-15"
}
```

Visual Flow (Student Reg)

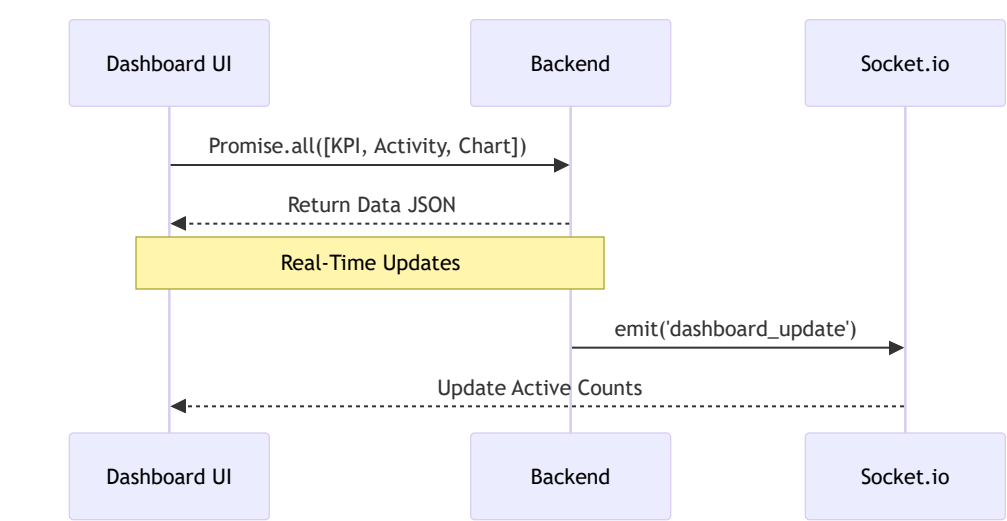


12.6. Dashboard: Initialization

Route: `/dashboard`

- 1. **Parallel Load:**
 - `GET /api/dashboard/kpi` -> Returns `{ books: 1200, students: 450, issued: 45 }`.
 - `GET /api/dashboard/activity` -> Returns `[{ action: "ISSUE", details: "...", time: "10:30 AM" }]`.
- 2. **Socket Event** (`dashboard_update`):
 - Backend emits JSON diff when any user issues/returns a book.
 - Frontend merges diff into state (Live Counter update).

Visual Flow (Dashboard)



12.7. Staff: RBAC Configuration

Route: `/dashboard/staff`

- 1. **Create Payload** (`POST /api/staff`):

```

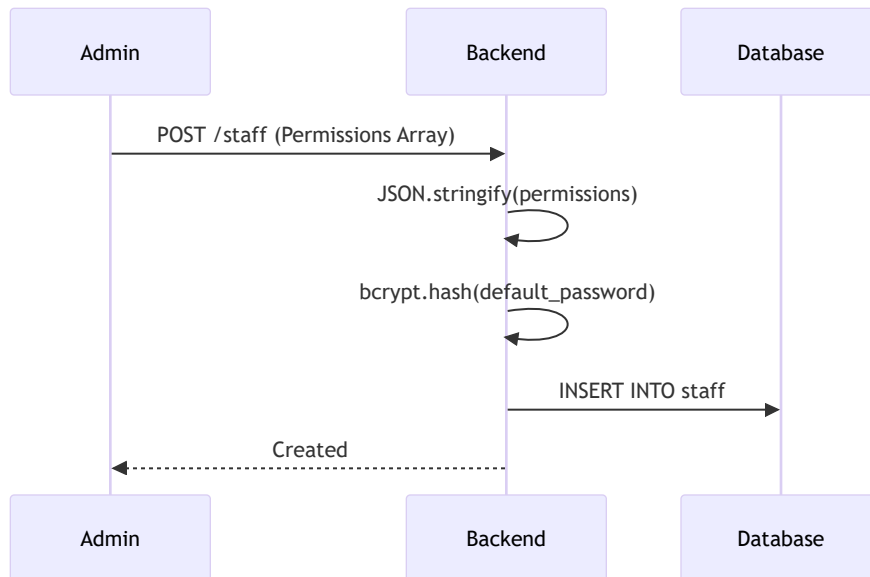
{
  "name": "Librarian A",
  "email": "lib@gptk.bed",
  "permissions": ["CIRCULATION", "MEMBERS", "CATALOG"] // JSON Array
}

```

2. DB Storage:

- Permissions stored as serialized JSON string: `'["CIRCULATION", "MEMBERS", "CATALOG"]'`.

Visual Flow (Staff RBAC)



12.8. Smart Backup (Background Service)

Service: `cloudBackupService.js`

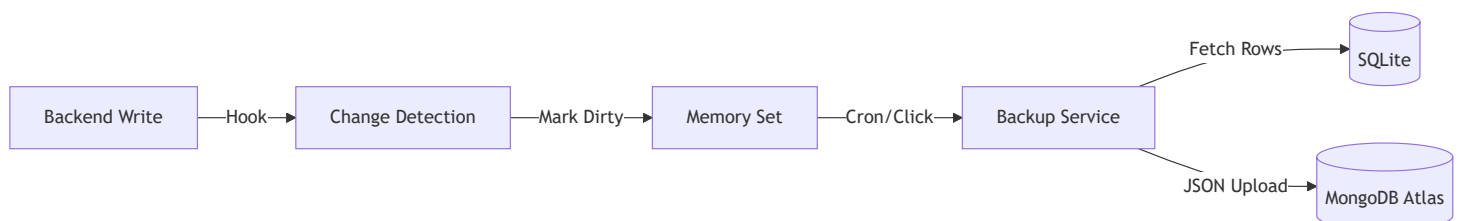
- Trigger:** `changeDetection` service marks table `circulation` as Dirty.
- Sync Payload** (Sent to MongoDB):

```

{
  "table": "circulation",
  "rows": [ ... ], // Full table dump or Delta
  "timestamp": 1740000000
}

```

Visual Flow (Smart Backup)



12.9. Fine Collection (Payment)

Route: `/dashboard/fines`

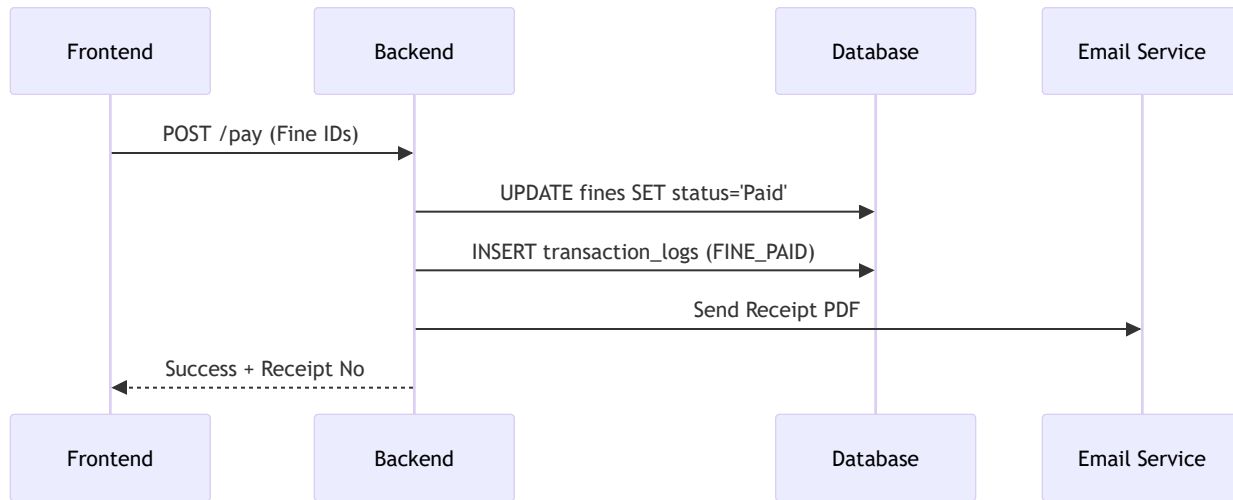
- Pay Request** (`POST /api/fines/pay`):


```
{
  "fine_ids": ["uuid-fine-1", "uuid-fine-2"],
  "payment_mode": "Cash",
  "remarks": "Paid at counter"
}
```

2. Response:

```
{
  "success": true,
  "receipt_no": "REC-2026-8871",
  "total_paid": 50.00
}
```

Visual Flow (Payment)



12.10. Reports: Generator

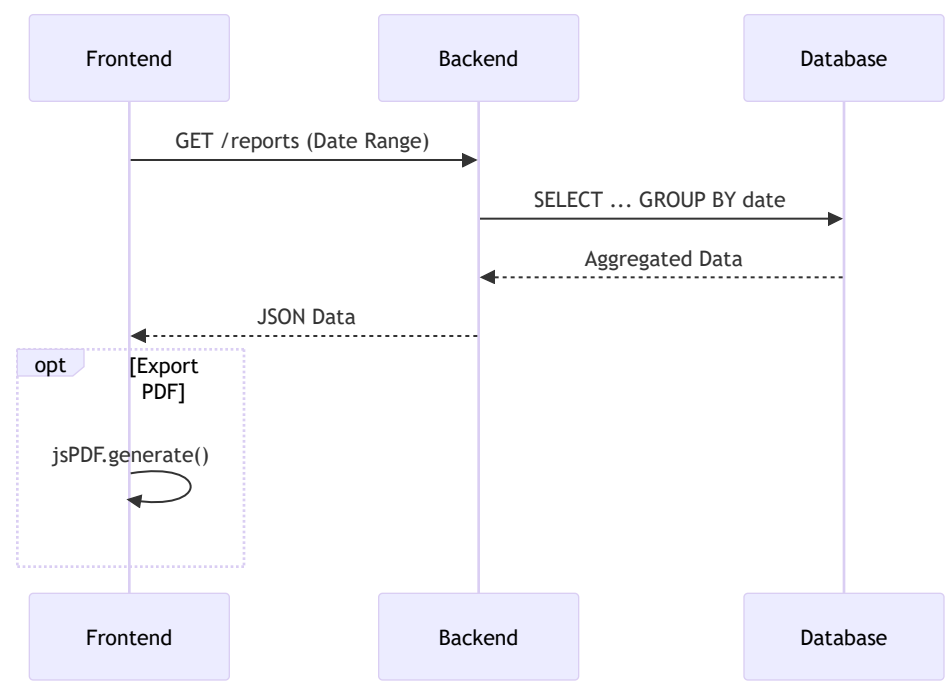
Route: /dashboard/reports

1. **Query Params:** GET /api/reports/txn?start=2026-01-01&end=2026-01-31

2. **Response** (Array of Objects):

```
[
  { "date": "2026-01-05", "issued": 12, "returned": 8, "fines_collected": 120.0 },
  { "date": "2026-01-06", "issued": 15, "returned": 10, "fines_collected": 50.0 }
]
```

Visual Flow (Reports)



12.11. Settings Configuration

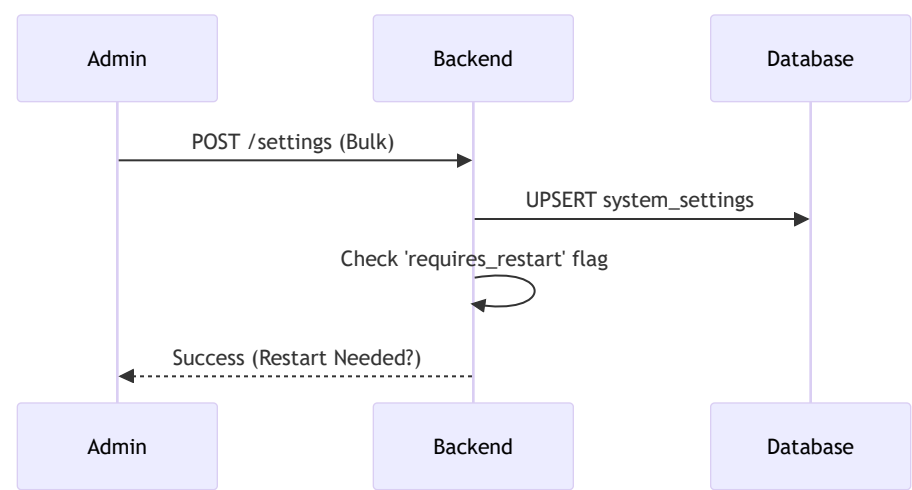
Route: /dashboard/settings

```
1. Update Payload ( POST /api/settings ):

{
  "settings": [
    { "key": "app.header_title", "value": "My Library" },
    { "key": "server.port", "value": "3002" } // requires_restart: true
  ]
}
```

2. Effect:
- **DB:** Updates system_settings table.
 - **Response:** { "success": true, "restart_required": true } if Port/Path changed.

Visual Flow (Settings)



12.12. Broadcast: Bulk Email

Route: /dashboard/notifications

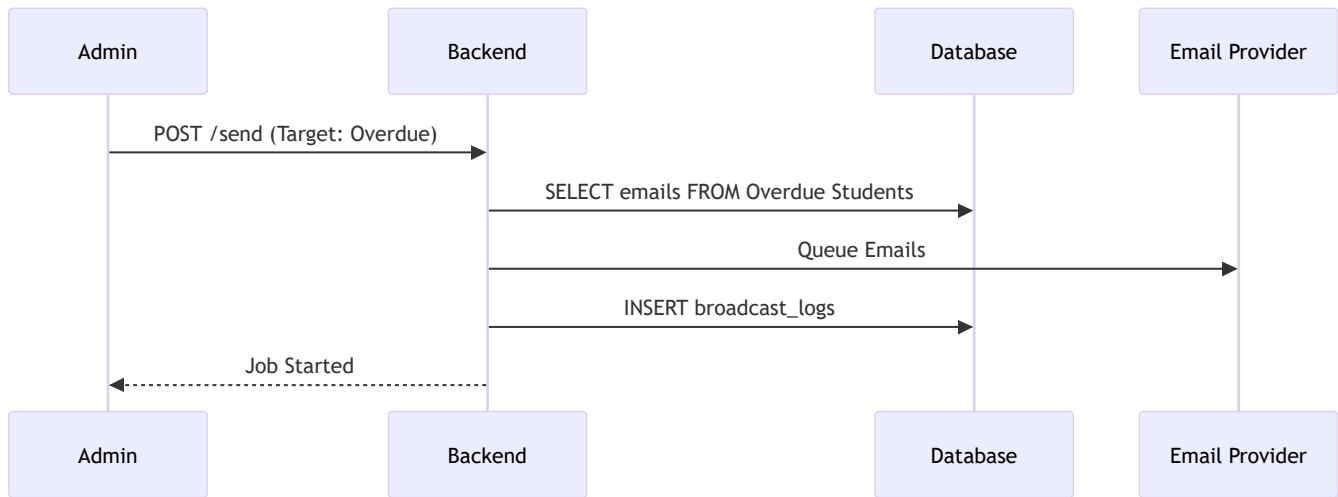
1. **Send Request** (POST /api/notifications/send):

```
{
  "target_group": "OVERDUE_STUDENTS",
  "subject": "Return Reminder",
  "body": "<p>Please return books by Monday.</p>", // HTML
  "force_send": false
}
```

2. **Backend Job:**

- **Query:** SELECT email FROM students WHERE id IN (SELECT student_id FROM circulation) .
- **Queue:** Adds 50 emails to nodemailer .
- **Log:** Inserts broadcast_logs (Status: 'Processing').

Visual Flow (Broadcast)



12.13. Password Recovery (3-Step)

Route: /forgot-password

1. **Request OTP** (POST /api/auth/forgot-password):

- **Input:** { "email": "staff@college.edu" }
- **DB:** Inserts { email, otp: "123456", expires_at: "..." } into password_resets .

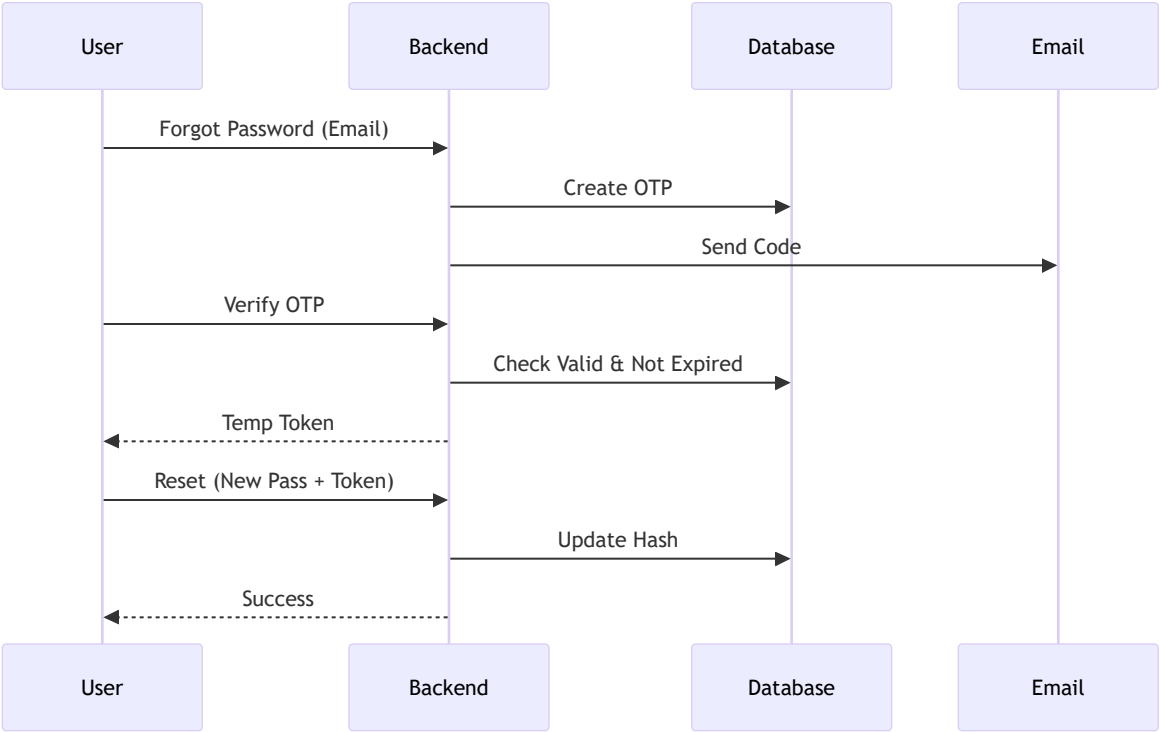
2. **Verify OTP** (POST /api/auth/verify-otp):

- **Input:** { "email": "...", "otp": "123456" }
- **Response:** { "valid": true, "temp_token": "zx99..." } (Used for step 3).

3. **Reset** (POST /api/auth/reset-password):

- **Input:** { "new_password": "...", "temp_token": "..." }
- **Action:** Hashes new password -> Updates Staff DB.

Visual Flow (Password Reset)

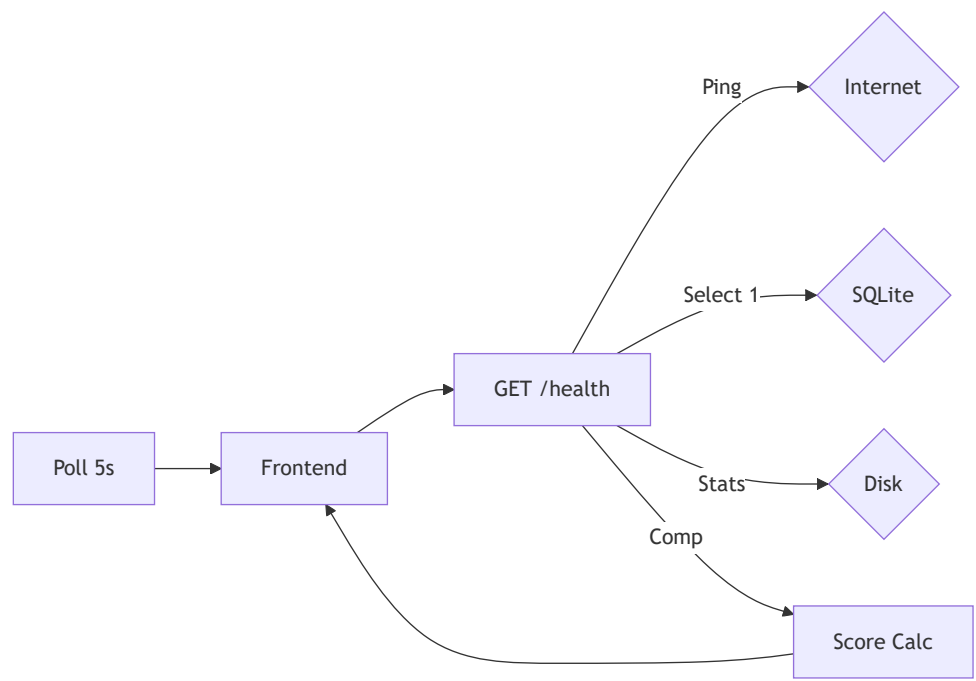


12.14. System Health Diagnostics

Route: /dashboard/health

```
1. Response ( GET /api/health ):  
  
  {  
    "os": { "cpu_load": 12, "freemem": 4096 }, // % and MB  
    "db": { "connected": true, "latency_ms": 2 },  
    "network": { "internet": true, "ping_ms": 45 },  
    "storage": { "used_percent": 34, "path": "D:/AppData" },  
    "score": 98 // Computed 0-100  
  }
```

Visual Flow (Health)

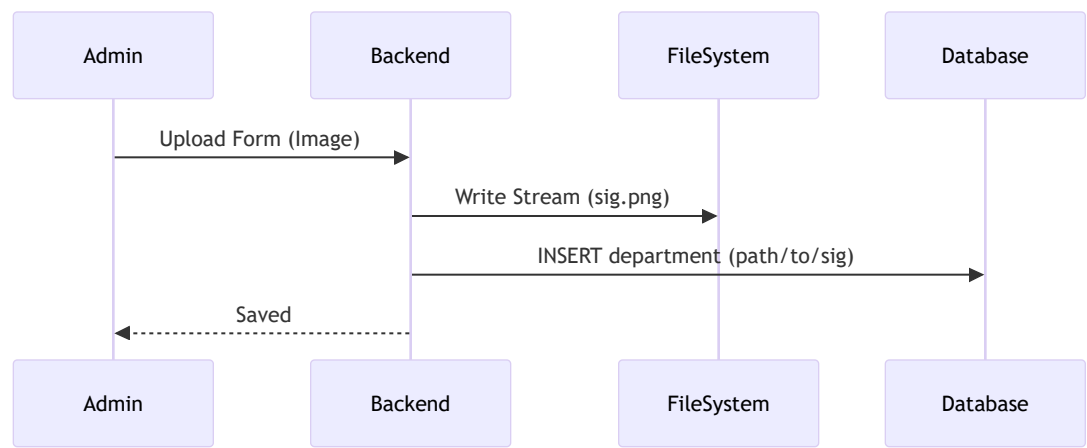


12.15. Departments: Signature Upload

Route: /dashboard/departments

- 1. Upload (POST /api/departments):
 - Headers: Content-Type: multipart/form-data
 - Form Data: name="Civil", code="CV", signature=[File Blob]
- 2. Storage:
 - File: Saves image to UserData/Uploads/signatures/sig-cv.png .
 - DB: Stores path uploads/signatures/sig-cv.png in hod_signature column.

Visual Flow (Signature)



12.16. Policy Security Gate

Route: /dashboard/policy

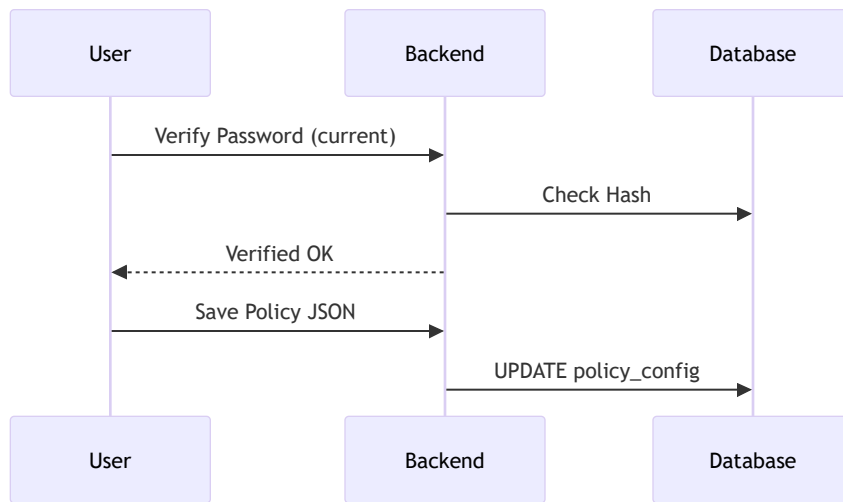
- 1. Verification (POST /api/auth/verify-password):
 - Input: { "password": "entered_admin_pass" }
 - Response: { "verified": true } (Allows frontend to unlock "Save" button).
- 2. Save Policy (POST /api/policy):

```

{
  "category": "policy_financial",
  "value": { "dailyFineRate": 2.0, "lostFineAmount": 600 } // JSON Stringified
}

```

Visual Flow (Secure Edit)



12.17. History: Traceability

Route: /dashboard/history

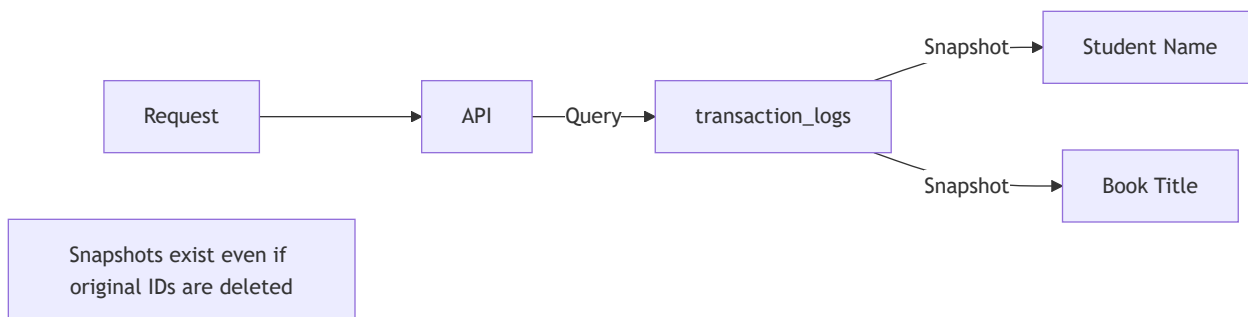
1. **Query:** GET /api/history?limit=20
2. **Response** (Joined Data):

```

[
  {
    "id": "txn-001",
    "action_type": "RETURN",
    "student_name": "Alice (SNAPSHOT)", // From transaction_logs
    "book_title": "Physics Vol 1 (SNAPSHOT)",
    "timestamp": "2026-01-28T10:00:00Z"
  }
]

```

Visual Flow (History Trace)



12.18. Audit Logs (Metadata)

Route: /dashboard/audit

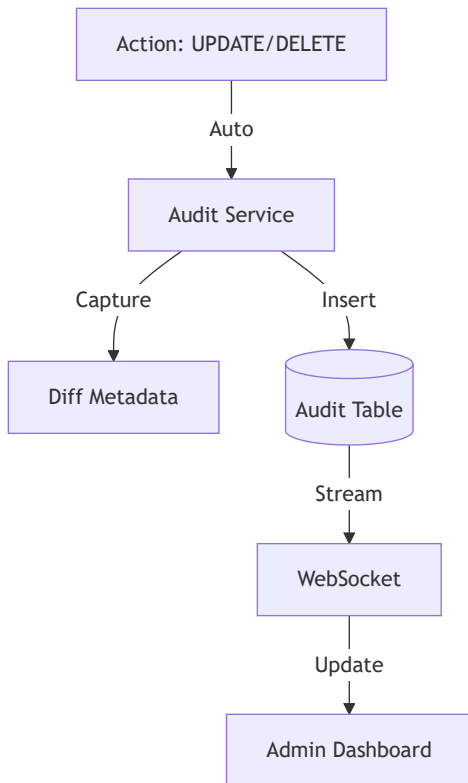
1. **Response Item:**

```

{
  "actor": "Admin",
  "action": "CONFIG_CHANGE",
  "description": "Changed Fine Rate",
  "metadata": {
    "old_value": "1.0",
    "new_value": "2.0"
  }
}

```

Visual Flow (Audit Logic)



12.19. Profile: Change Password

Route: /dashboard/profile

1. **Payload** (POST /api/auth/change-password):

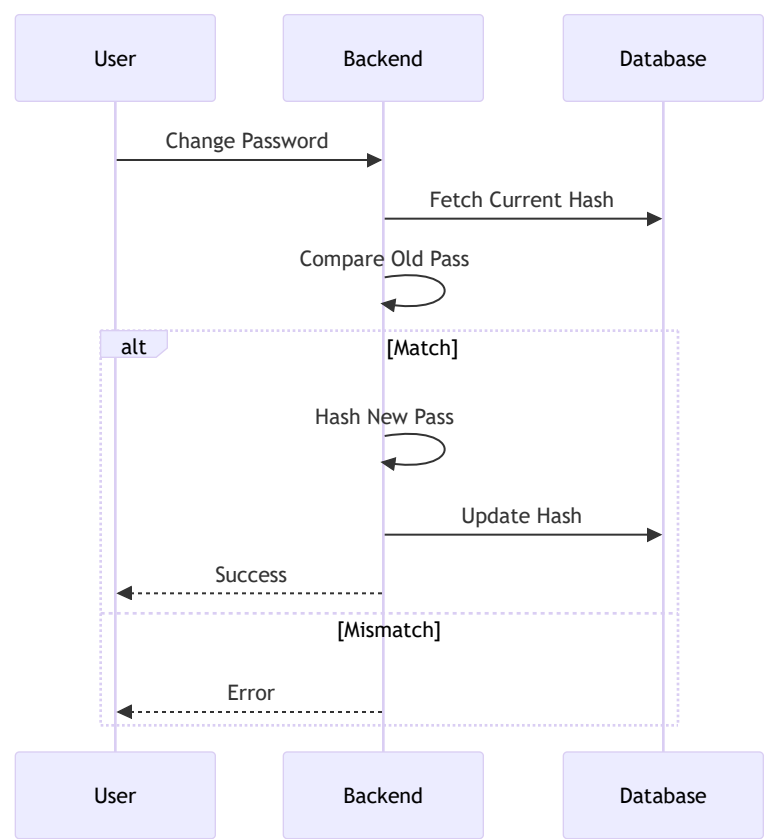
```

{
  "old_password": "current_pass",
  "new_password": "secure_new_pass"
}

```

2. **Validation:** Fails if old_password hash mismatch.

Visual Flow (Pass Change)

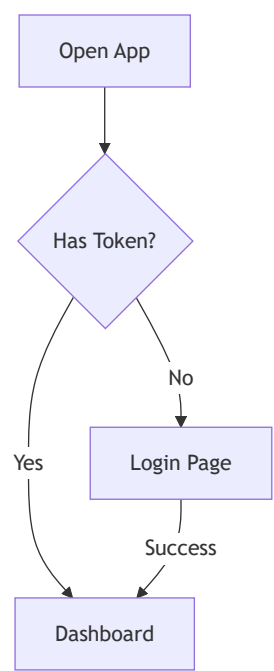


12.20. Landing Page (Gateway)

Route: /

1. **Asset Load:**
- GET /api/settings/public -> Returns { "header_title": "GPTK", "theme": "Dark" } .
 - **Check:** If auth_token in localStorage -> Redirect /dashboard .
 - **Fallback:** Render Login Form.

Visual Flow (Gateway)

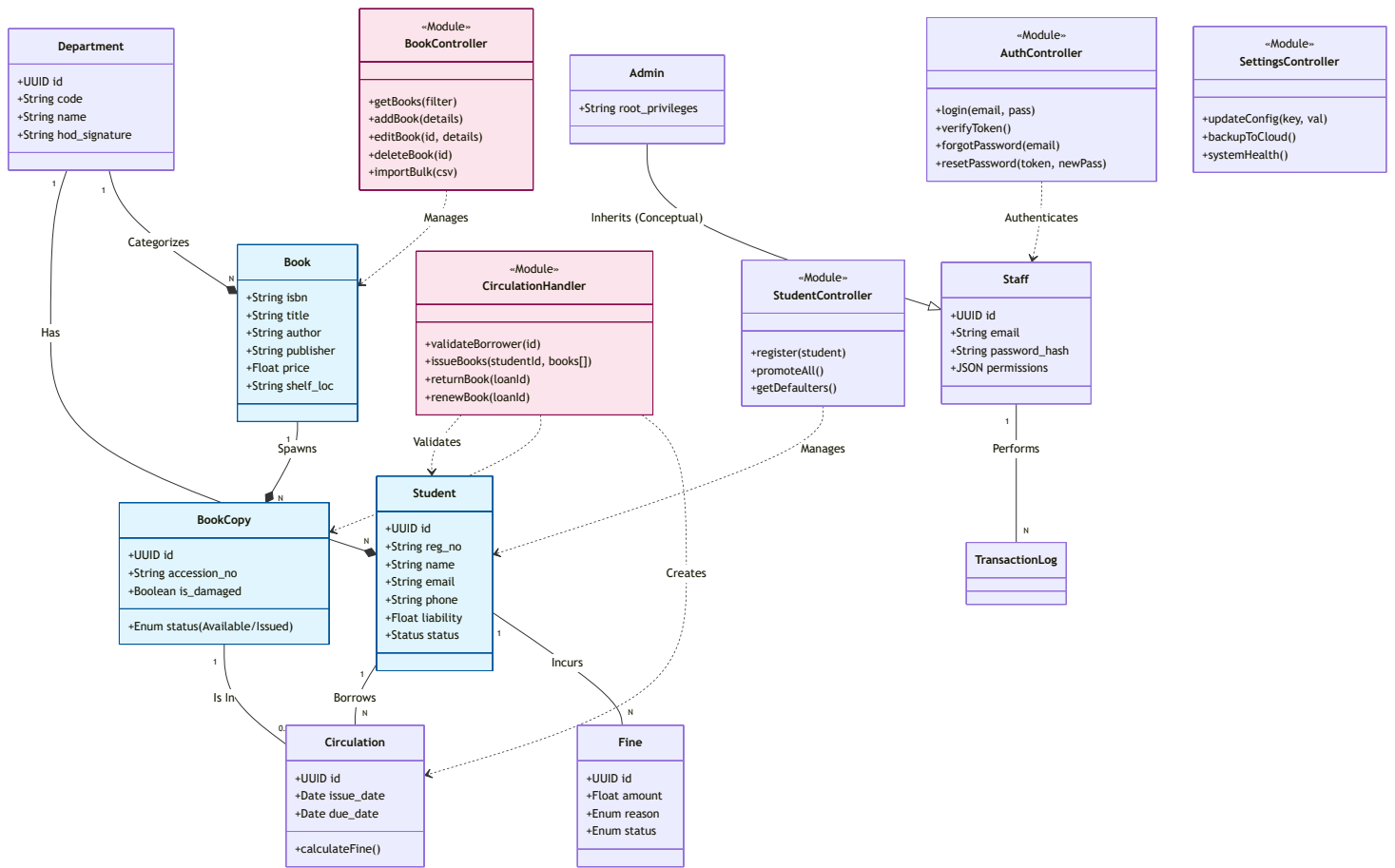


13. System Class Structure (UML)

This section represents the system's static structure using **UML Class Diagrams**. It bridges the gap between the Relational Database (Entities) and the Backend Logic (Controllers).

13.1. Domain Model & Controller Architecture

This "Grand Class Diagram" visualizes the **Data Entities** (with their fields) and the **Controller Modules** (with their public methods) that manage them.



14. User Interface Specifications

This section defines the granular visual structure, component properties, and interaction behaviors for every screen.

12.1. Login Screen

Route: /login (Public)

Visual Layout: Split Screen (Left: 50% Brand Image, Right: 50% Auth Form centered vertically).

Element ID	Type	Data Binding	Props / State
img_brand	Image	settings.brand_logo	Fit: Cover
inp_email	Input	auth.email	Placeholder: "admin@college.edu", AutoFocus
inp_pass	Password	auth.password	Toggle: Show/Hide
btn_login	Button	-	State: Loading (Spinner) when submitting
lnk_forgot	Link	-	Href: /forgot-password

Operations:

- Submit:** POST /api/auth/login . On 401: Shake animation + Toast "Invalid Credentials".
- Setup Check:** On mount, GET /api/setup . If count(admins) == 0 , redirect /setup .

12.2. Dashboard (Hub)

Route: /dashboard (Private)

Visual Layout: Grid Layout (Header: Fixed Top, Sidebar: Collapsible Left, Content: Scrollable).

Element ID	Type	Data Binding	Props / State
kpi_books	Card	stats.total_books	Icon: BookOpen , Color: Blue
kpi_users	Card	stats.active_students	Icon: Users , Color: Green
kpi_issued	LiveCard	socket:circulation.active	Badge: "Live"
chart_circ	LineChart	reports.weekly_trend	X: Date, Y: Count
wid_due	List	circulation.due_today	Max: 5 items, Action: "Remind"

12.3. Circulation Interface

Route: /dashboard/circulation

Visual Layout: Tabbed View (Tabs: Issue, Return, Renew).

Tab F1: Issue Book

Element ID	Type	Data Binding	Props / State
inp_student	PID Input	txn.student_id	Debounce: 500ms, OnEnter: Fetch Profile
pnl_profile	Card	student.details	State: Hidden
badge_status	Label	student.status	Red="Blocked", Green="Active"
inp_book	Barcode	txn.book_ids[]	Mode: Multi-scan (Array)
tbl_cart	Table	txn.book_list	Cols: Title, DueDate, RemoveBtn

Logic:

- **Liability Check:** If student.unpaid_fines > config.limit -> Disable btn_confirm + Show Alert.
- **Quota Check:** If current_loans + cart_size > config.max_loans -> Show "Quota Exceeded".

Tab F2: Return Book

Element ID	Type	Data Binding	Props / State
inp_ret_scan	Barcode	-	Auto-submit on scan
lbl_overdue	Alert	calc.overdue_days	Show only if > 0
rad_condition	Radio	txn.condition	Opts: Good, Damaged, Lost
btn_ret_conf	Button	-	Variant: Danger (if fines exist)

12.4. Student Management

Route: /dashboard/students

Visual Layout: Master-Detail (Table with Sidebar Filter).

Element ID	Type	Data Binding	Props / State
flt_dept	Select	depts.list	Multi-select
tbl_students	DataTable	students.data	Pagination: Server-side
btn_add	ModalTrigger	-	Opens mdl_student
btn_import	FileUpload	-	Accept: .csv, .xlsx

Modal: Add Student (mdl_student)

- **Fields:** Name, RegNo (Unique), Email (Unique/Optional), Phone.
- **Validation:** RegNo must match Regex `^[0-9A-Z]+$` .

12.5. Book Catalog

Route: /dashboard/books

Visual Layout: Card Grid or Table (Toggleable).

Element ID	Type	Data Binding	Props / State
inp_search	SearchBar	query.q	Scope: Title, Author, ISBN
row_expander	Button	book.copies	Expands to show Accession List
lbl_stock	Badge	book.avail_qty	Format: "3 / 5 Available"
btn_print_qr	Action	book.id	Generates QR PDF

12.6. Staff & Admin (RBAC)

Route: /dashboard/staff

Visual Layout: List Group .

Element ID	Type	Data Binding	Props / State
lst_staff	Repeater	staff.list	Item: Avatar, Name, Role
chk_perm_*	Checkbox	staff.permissions	Dynamic keys (e.g., perm_issue)
sw_active	Toggle	staff.is_active	Immediate API call on change
btn_reset	Action	staff.id	Shows "Copy Temp Password" dialog

12.7. Reports Center

Route: /dashboard/reports

Visual Layout: Sidebar Controls + Preview Pane .

Element ID	Type	Data Binding	Props / State
rng_date	DatePicker	filters.range	Default: Current Month
sel_type	Select	report.type	Opts: Issues, Returns, Fines, Stock
view_html	Table	preview.data	Read-only, Scrollable
btn_pdf	BlobAction	-	Triggers jsPDF render
btn_csv	Download	-	Triggers CSV Stream

12.8. Settings & Configuration

Route: /dashboard/settings

Visual Layout: Vertical Tabs .

Element ID	Type	Data Binding	Props / State
inp_inst_name	Input	config.header_title	Requires Restart: No
inp_fine_amt	Currency	policy.fine_per_day	Locked (Requires Auth)
btn_test_prn	Action	hardware.printer	Sends test payload to thermal printer
log_sync	Terminal	sync.logs	Tail: 50 lines

Security Gate:

- Editing policy.* triggers mdl_auth . Input: admin_password . Logic: Verify Hash -> Unlock Field.

12.9. Broadcast Notifications

Route: /dashboard/notifications

Visual Layout: Composer View .

Element ID	Type	Data Binding	Props / State
sel_target	RadioGroup	msg.target	Opts: All, Due<3d, Overdue, Dept
edt_body	RichText	msg.html_content	Toolbar: Bold, Link, List
prg_send	ProgressBar	job.progress	Visible only during sending
txt_status	Log	job.status	"Sent 45/100..."

12.10. Fine Collection (Cashier)

Route: /dashboard/fines

Visual Layout: Split Pane (checkout style).

Element ID	Type	Data Binding	Props / State
pnl_due	BigDisplay	student.total_due	Color: Red, Size: XL
chk_item_{id}	Checkbox	fine.selected	OnChange: Updates total_pay
sel_mode	Segmented	txn.mode	Cash
btn_collect	Button	txn.amount	"Collect â,150.00"

12.11. Departments Management

Route: /dashboard/departments

Element ID	Type	Data Binding	Props / State
crd_dept	Card	dept	Header: Code, Body: Name
img_sig	Preview	dept.signature	MaxHeight: 50px
upl_sig	FileInput	-	Target: uploads/signatures/

12.12. Transaction History

Route: /dashboard/history

Element ID	Type	Data Binding	Props / State
tbl_txns	Table	history.logs	RowColor: Issue(Blue), Ret(Green)
flt_type	Chips	query.type	Filter by Action Type
btn_reprint	Icon	txn.id	Re-generates Receipt PDF

12.13. Audit Logs (Security)

Route: /dashboard/audit

Element ID	Type	Data Binding	Props / State
strm_logs	Table	socket:audit.new	Prepend new rows

Element ID	Type	Data Binding	Props / State
mdl_diff	DiffView	log.metadata	Shows Red/Green text diff
btn_export	Action	-	Dumps all to .csv

12.14. System Health

Route: /dashboard/health

Visual Layout: Dashboard Gauge Cluster .

Element ID	Type	Data Binding	Props / State
gauge_cpu	Radial	os.cpu_load	>80% = Red
gauge_ram	Bar	os.free_mem	Tooltip: "4GB / 16GB Used"
ind_db	Dot	db.status	Green=OK, Red=Error
ind_net	Dot	net.online	Ping: google.com

12.15. User Profile

Route: /dashboard/profile

Element ID	Type	Data Binding	Props / State
pwd_curr	Password	-	Validation: Must match hash
pwd_new	Password	-	Validation: Min 8 chars, 1 Special
tgl_theme	Switch	pref.theme	Updates CSS Variables root

12.16. Forgot Password Flow

Route: /forgot-password (Wizard)

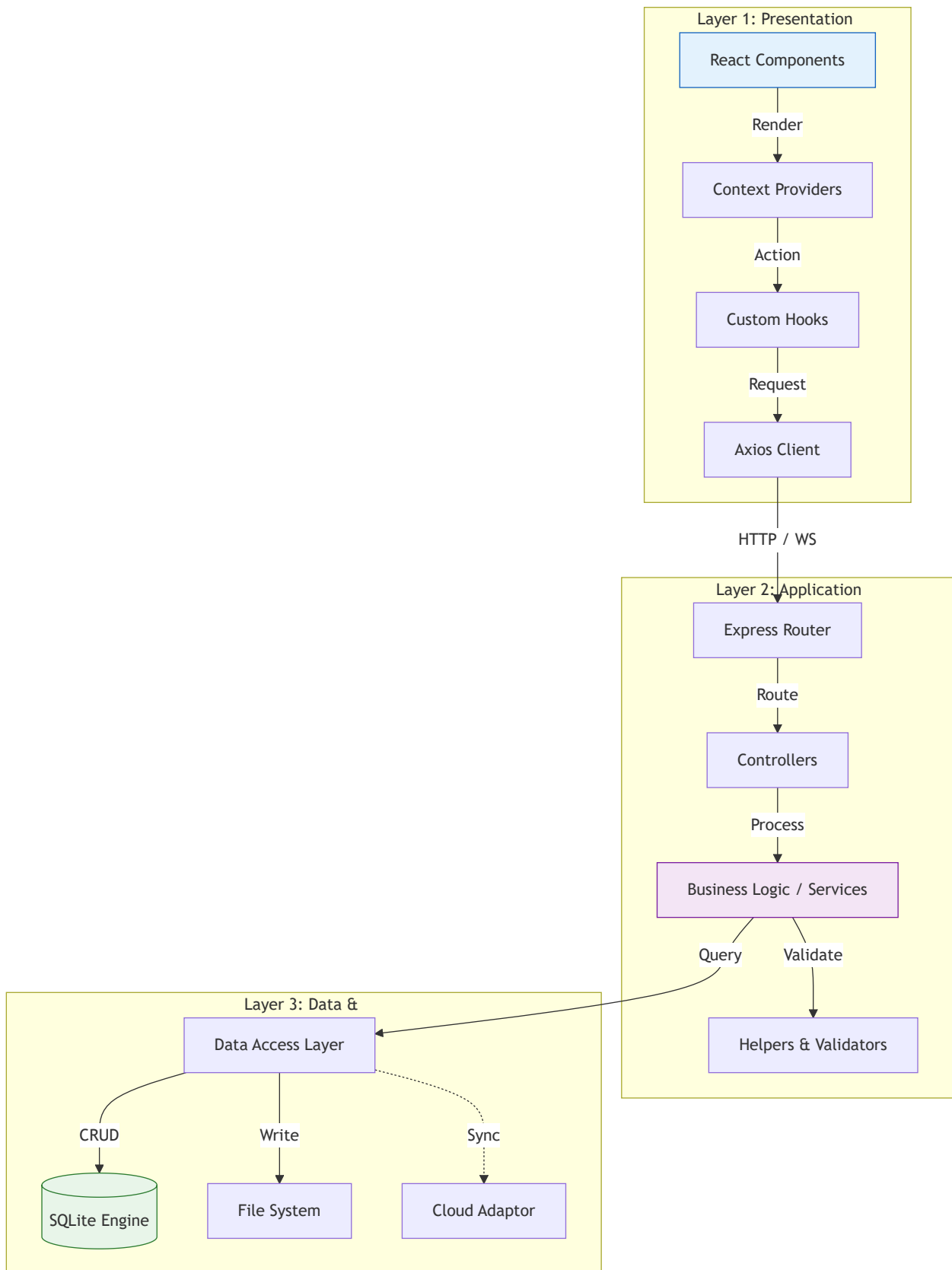
Element ID	Type	Data Binding	Props / State
step_1	Form	-	Input: Email -> POST /otp
inp_otp	NumPad	flow.otp	Local State: 6 chars
timer_resend	Text	flow.timer	"Resend in 30s"
step_3	Form	-	Input: NewPass -> PUT /reset

15. Advanced System Architecture

This section details the internal component design, layering, and process management that powers the hybrid desktop application.

13.1. Layered Architecture Diagram

The system follows a strict **Separation of Concerns (SoC)** pattern, divided into three horizontal layers: Presentation, Application (Business), and Data.



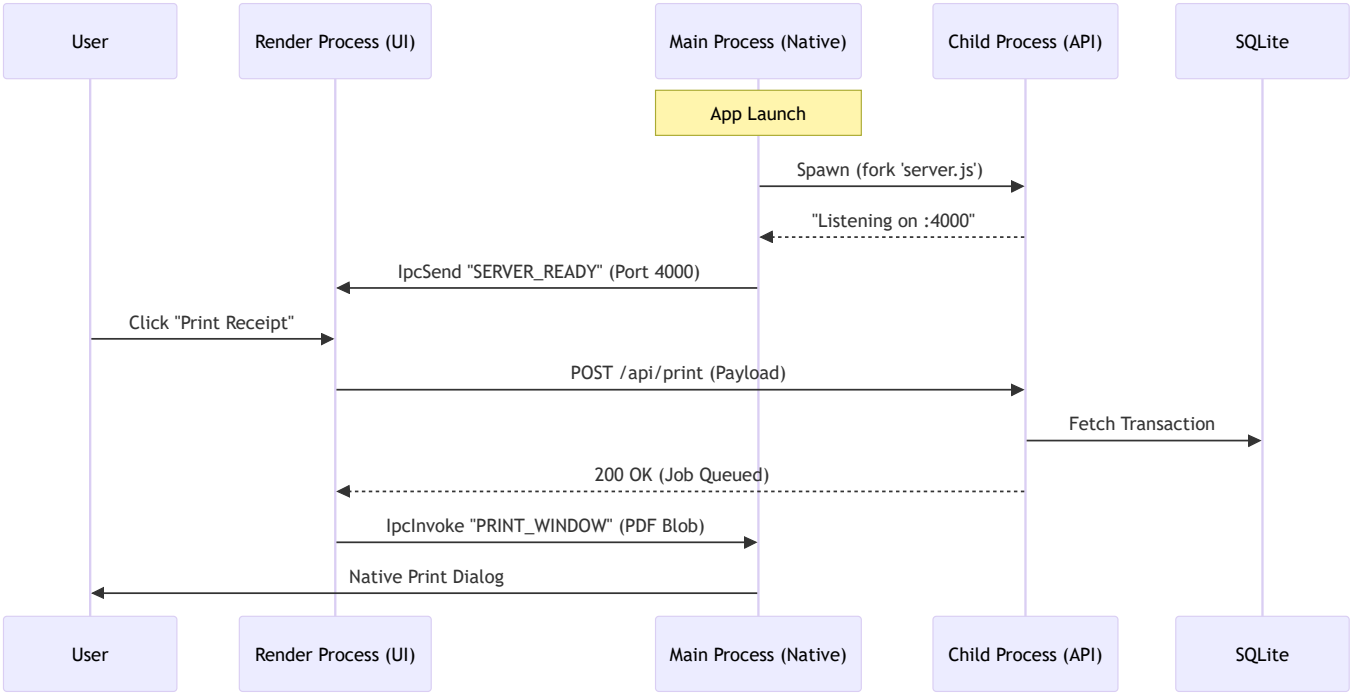
13.2. Component Interaction & IPC Bridge

Since the app runs as an Electron executable, it manages two distinct environments: the Node.js Main Process and the Chromium Renderer Process.

Process Model

1. **Main Process (`main.js`)**: The entry point. It creates the GUI window and spawns the backend server.

- **Responsibility:** OS Integration (Menus, Tray), Window Management, Auto-Updater.
 - **Child Process:** Spawns the Express Server (`server.js`) on a random available port (default 4000).
2. **Renderer Process (`React App`):** The UI logic.
- **Responsibility:** DOM Rendering, State Management, API Calls.
 - **Security:** `contextIsolation: true` , `nodeIntegration: false` . Accesses OS features only via `window.electron` bridge.



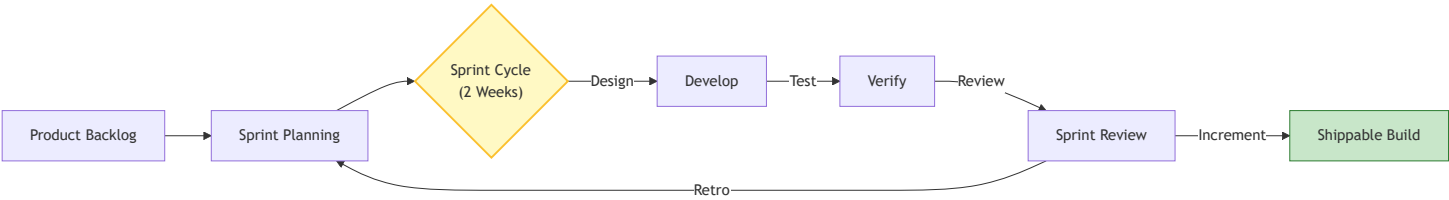
13.3. Design Patterns

- **Repository Pattern:** Database queries are abstracted in helper functions (`getStudent` , `updateBook`), keeping Controllers clean.
- **Observer Pattern:** The backend uses `Socket.io` to "push" updates (e.g., Audit Logs, Dashboard Counters) to all connected clients instantly.
- **Singleton:** The Database Connection (`db.js`) is initialized once and reused across the entire backend lifecycle.
- **Factory Pattern:** Used in `ReportGenerator` to instantiate different report types (PDF, CSV, HTML) based on user selection.

16. Project Implementation Roadmap (Agile Scrum)

This project adopts the **Agile Scrum Methodology**, continuously delivering functional "vertical slices" of the application in **2-week Sprints**. This ensures rapid feedback and early detection of integration issues.

14.1. Agile Process Flow



14.2. Sprint Schedule (16 Weeks)

Each Sprint includes Analysis, Design, Dev, and Testing for its specific feature set.

Sprint	Timeline	Focus Feature (Vertical Slice)	Key Deliverables (Shippable Increment)
Sprint 1	Week 1-2	Zero To One (Foundation)	<ul style="list-style-type: none">• Repo & Environment Setup (Electron/React/Node)• DB Schema v1.0 (SQLite)

Sprint	Timeline	Focus Feature (Vertical Slice)	Key Deliverables (Shippable Increment)
			<ul style="list-style-type: none"> • Feature: User Login & Auth (JWT/RBAC) • Outcome: Admin can log in/out.
Sprint 2	Week 3-4	Catalog Management	<ul style="list-style-type: none"> • Book CRUD API & UI • Bulk Import (CSV) Logic • Barcode Generation Logic • Outcome: Staff can add/upload books.
Sprint 3	Week 5-6	Member Operations	<ul style="list-style-type: none"> • Student Registration API & UI • Student Bulk Import • Department Signature Upload • Outcome: Database populated with Students & Books.
Sprint 4	Week 7-8	Circulation Core	<ul style="list-style-type: none"> • Issue / Return Transaction Engine • "Cart" System for batch issue • Validation Rules (Limits/Overdue) • Outcome: Books can be issued to Students.
Sprint 5	Week 9-10	Financials & Dashboard	<ul style="list-style-type: none"> • Fine Calculation Service (Cron/Trigger) • Payment Collection UI • Admin Dashboard (KPI Cards) • Outcome: Fines generated and collected.
Sprint 6	Week 11-12	Reports & Settings	<ul style="list-style-type: none"> • Report Generator (PDF/Excel) • System Settings (Policy config) • Email Notifications (SMTP) • Outcome: Admins can export data and change rules.
Sprint 7	Week 13-14	Hardening & Audit	<ul style="list-style-type: none"> • Security Audit (SQLi/XSS checks) • Cloud Sync (Backup Service) • Audit Logs Visualizer • Outcome: System is secure and backed up.
Sprint 8	Week 15-16	Final Polish	<ul style="list-style-type: none"> • End-to-End Regression Testing • Installer Packaging (.exe/.msi) • User Manual Finalization • Outcome: Production Release v1.0

17. Coding Standards & Best Practices

To ensure maintainability and consistency, all development must adhere to the following standards.

15.1. Naming Conventions

Type	Standard	Example
Variables	camelCase	studentName , isActive
Functions	camelCase	calculateFine() , fetchBooks()
Classes/Components	PascalCase	BookCard.js , CirculationService
Constants	UPPER_SNAKE_CASE	MAX_LOAN_LIMIT , API_BASE_URL
Database Tables	snake_case (Plural)	book_copies , transaction_logs
Routes	kebab-case	/api/users/change-password

15.2. Project Folder Structure Diagram

The project uses a **Monorepo-style** structure, separating the Electron host, React frontend, and Node.js backend. This diagram details the **exact file organization** of the codebase.

```

GPTK-Library-Management-System/
├─ 📁 .github/                # CI/CD Workflows
├─ 📁 Docs/                   # Documentation (SRS, User Manual, Test Cases)
├─ 📁 electron/               # [HOST] Electron Main Process
│   ├── main.js               # Application Entry Point & Window Management
│   ├── preload.js            # IPC Bridge (Context Isolation)
│   └─ splash.html            # Splash Screen (Loading UI)
├─ 📁 backend/                # [SERVER] Node.js Express API
│   ├── 📁 controllers/       # Business Logic Layer
│   │   ├── adminController.js # Admin Management
│   │   ├── auditController.js # System Audit Logs
│   │   ├── authController.js  # Login, Logout, Session
│   │   ├── bookController.js  # Catalog CRUD Operations
│   │   ├── circulationHandler.js # Issue/Return/Renew Logic
│   │   ├── dashboardController.js # KPI & Stats Aggregation
│   │   ├── fineController.js  # Fine Calculation & Payment
│   │   ├── reportsController.js # PDF/Excel Generation
│   │   ├── settingsHandler.js # System Configuration
│   │   ├── staffController.js # Staff Role Management
│   │   ├── studentController.js # Student Registration
│   │   └─ healthController.js # Health Checks
│   ├── 📁 routes/            # API Endpoint Definitions
│   │   ├── adminRoutes.js
│   │   ├── authRoutes.js
│   │   ├── bookRoutes.js
│   │   ├── circulationRoutes.js
│   │   ├── fineRoutes.js
│   │   ├── reportsRoutes.js
│   │   ├── settingsRoutes.js
│   │   └─ studentRoutes.js
│   ├── 📁 database/          # Data Access Layer
│   │   └─ db.js              # SQLite Connection & Init
│   ├── 📁 middleware/        # Request Processing
│   │   ├── auth.js           # JWT Verification
│   │   └─ upload.js          # Multer File Handling
│   └─ server.js              # API Server Bootstrapper
├─ 📁 frontend/               # [CLIENT] React Application
│   ├── 📁 public/            # Static Assets
│   └─ 📁 src/
│       ├── 📁 components/    # UI Component Library
│       │   ├── 📁 common/    # Shared Atoms (Buttons, Inputs, Modals)
│       │   ├── 📁 books/      # BookCatalog, BookForm
│       │   ├── 📁 circulation/ # IssueBook, ReturnBook, Cart
│       │   ├── 📁 layout/     # Sidebar, Navbar, MainLayout
│       │   ├── 📁 students/   # StudentList, StudentForm
│       │   └─ 📁 dashboard/   # KPICard, Charts
│       ├── 📁 context/        # Global State
│       │   ├── SessionContext.js # Auth User State
│       │   ├── LanguageContext.js # i18n Data
│       │   └─ SocketContext.js  # Real-time Events
│       ├── 📁 pages/          # Full Page Views (Routes)
│       │   ├── CatalogPage.js  # Book Management
│       │   ├── CirculationPage.js # Issue/Return Desk
│       │   ├── DashboardHome.js # Main Hub
│       │   ├── LoginPage.js     # Auth Entry
│       │   ├── ReportsPage.js   # Analytics Center
│       │   └─ SettingsPage.js   # Config Panel

```

			StaffManager.js	# Employee Roles
			StudentManager.js	# Student Records
			UserProfile.js	# Personal Account
			hooks/	# Custom React Hooks
			services/	# API Client (Axios)
			App.js	# React Root
			index.js	# DOM Entry
			build/	# Installer Artifacts
			package.json	# Project Manifest
			README.md	# Quick Start

15.3. Documentation & Comments

- **JSDoc:** All major functions must have header comments.

```
/**
 * Calculates the overdue fine for a given transaction.
 * @param {string} dueDate - ISO Date string.
 * @param {number} dailyRate - Fine per day.
 * @returns {number} Total fine amount.
 */
```

- **Inline Comments:** Use `//` only for complex logic explanation, not for obvious code.
- **TODOs:** Mark pending work with `// TODO: [Description]`.

15.4. Error Handling Strategy

Backend

1. **Try-Catch:** Wrap *all* async controller operations in try-catch.
2. **Standard Response:**

```
{
  "success": false,
  "message": "User not found", // Human readable
  "error": "ERR_USER_404"     // Machine code
}
```

3. **HTTP Codes:**

- 200 : Success
- 400 : Bad Request (Validation failed)
- 401 : Unauthorized (No Token)
- 403 : Forbidden (Low Permissions)
- 500 : Internal Server Error

Frontend

1. **Error Boundaries:** Wrap app in `<ErrorBoundary>` to catch crash loops.
2. **Toasts:** Display user-friendly error messages (e.g., "Network Error, please retry") instead of raw exceptions.
3. **Fallbacks:** Show "No Data Found" or Skeleton loaders instead of broken UI.

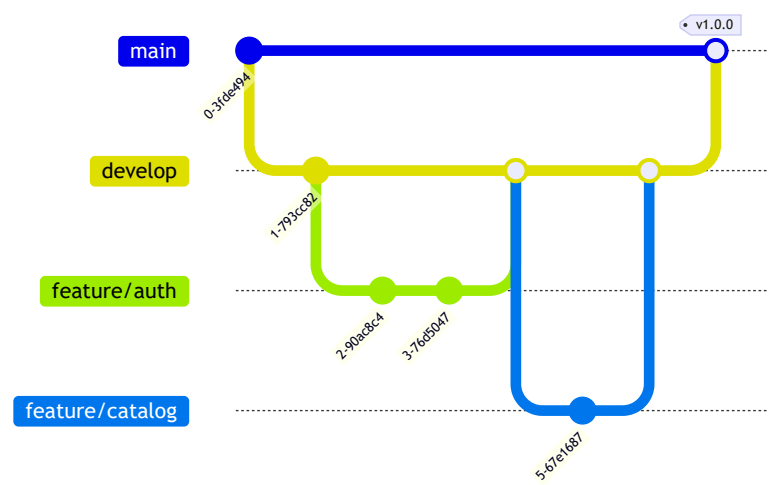
15.5. Version Control & Branching Strategy

We follow the **GitFlow** workflow to ensure a stable production ease and organized parallel development.

Branch Types

- `main` : **Production** code. Stable, deployed to users. (Protected Branch).
- `develop` : **Integration** branch. All new features are merged here for testing.
- `feature/*` : Individual tasks (e.g., `feature/login-ui`, `feature/book-api`). Created from `develop`, merged back to `develop`.
- `hotfix/*` : Urgent fixes for production bugs (e.g., `hotfix/login-crash`). Branches off `main`, merges to both `main` and `develop`.

Visual Git Workflow



Commit Message Convention

We adhere to **Conventional Commits** to auto-generate changelogs:

- feat: ... : A new feature (e.g., feat: add student registration form)
- fix: ... : A bug fix (e.g., fix: correct fine calculation logic)
- docs: ... : Documentation only changes
- style: ... : Formatting, missing semi-colons, etc (no code change)
- refactor: ... : Code restructuring without behavior change

Pull Request (PR) Process

1. **Sync:** Ensure feature branch is up-to-date with develop (git pull origin develop).
2. **Lint:** Run local linters/tests before pushing.
3. **Create PR:** Targets develop . Title must follow Commit Convention.
4. **Review:** Requires at least 1 **Peer Review**.
5. **Merge:** Squash and Merge to keep history clean.

18. Deployment & Operations Guide

This section outlines how to install, configure, and deploy the application in both development and production environments.

16.1. System Requirements

Hardware Prerequisites

- **Processor:** Dual Core 2.0 GHz or higher (Recommended: Quad Core).
- **RAM:** 4 GB Minimum (Recommended: 8 GB for development).
- **Storage:** 500 MB free space (plus database growth).
- **OS:** Windows 10/11 (Primary Target), macOS 10.15+, or Linux (Ubuntu 20.04+).

Software Prerequisites (For Source Installation)

- **Node.js:** v18.x or v20.x (LTS).
- **Git:** v2.30+.
- **Python:** v3.10+ (Required for node-gyp native modules if rebuilding).
- **Visual Studio Build Tools:** (Windows only) for native dependencies.

16.2. Installation Steps

A. Production Installation (End-User)

1. Download the latest installer ("GPTK Library Manager Setup 1.0.0.exe") from the Releases page.
2. Run the installer as Administrator.
3. The application will install to %AppData%\Local\Programs\gptk-library-management-system .
4. **First Run:**
 - The app initializes the database at: %APPDATA%\GPTK Library Manager\DB\lms.sqlite .
 - A default Admin account is created: veerkotresh@gmail.com / 123456 .

B. Development Setup (Source Code)

1. Clone Repository:

```
git clone https://github.com/kotresh75/gptk-library-system.git
cd gptk-library-management-system
```

2. Install Dependencies:

- **Root:** npm install (Installs concurrently & electron builder).
- **Backend:** cd backend && npm install .
- **Frontend:** cd frontend && npm install .

3. Start Development Mode:

From the root directory, run:

```
npm start
```

- **Backend:** runs on Port **3001** (<http://localhost:3001>).
- **Frontend:** runs on Port **3000** (<http://localhost:3000>).
- **Electron:** Launches and loads <http://localhost:3000> .

16.3. Configuration

System Settings (Database Managed)

Unlike traditional apps using .env , this system stores configuration in the system_settings table.

- **Port:** Defaults to 3001 .
- **App Title:** Defaults to "GPTK Library".
- **Policy Config:** Stored as JSON in policy_config table.

Database & Backups

- **Location:**
 - **Dev:** <ProjectRoot>/DB/lms.sqlite
 - **Prod:** %APPDATA%\GPTK Library Manager\DB\lms.sqlite
- **Smart Backup:**
 - The system uses a **Change Detection** mechanism.
 - If backup_on_close is enabled in settings, the system automatically backs up the database to the cloud/local archive **only if data was modified** during the session.
 - Shutdown logs can be found in the console/terminal.

19. User Manual

This section serves as a functional guide for end-users (Admins and Staff) interacting with the system.

17.1. Getting Started & System Setup

[!IMPORTANT]

First-Time Setup Instructions

Follow these steps precisely to initialize the application.

A. Initial Login

When you launch the application for the first time, use the default Administrator credentials:

- **Email:** veerkotresh@gmail.com
- **Password:** 123456

B. Database Configuration (Crucial)

1. Within the app, navigate to **Settings** (Gear icon on the sidebar).
2. Go to the **Data & Maintenance** section.
3. Locate the **Cloud Database Configuration** field.
4. Paste the Connection String provided by your IT Admin.
5. Click **Save Connection** and **Restart the Application**.

C. Data Restoration

1. Open the application and go back to **Settings > Data & Maintenance**.
2. Find the **Backup & Restore Operations** section.
3. Click the **Restore from Cloud** button to sync latest data.

17.2. Module Walkthrough

1. Dashboard

The landing screen provides a real-time overview of library health.

- **Key Metrics:** Total Books, Issued Books, Active Members, Overdue Returns.
- **Live Activity:** A stream of recent system actions (e.g., "Book Issued to John").
- **Graphs:** Visual breakdowns of Book Categories and Circulation Trends.

2. Catalog (Book Management)

Manage the library's physical inventory.

- **Add Book:**
 - Supports manual entry or **Smart Auto-Fill** (enter ISBN -> click Lightning icon).
 - **Bulk Import:** Upload .csv or .xlsx files. The system detects duplicates and fuzzy-matches headers.
- **Manage Copies:** Track individual physical copies of a book. Supports barcodes.
- **Search & Filter:** Find books by Title, Author, ISBN, or Department.

3. Members (Student Management)

Maintain student records.

- **Add Student:** Requires unique Register Number.
- **Promote/Demote:** Bulk moving of students between semesters (e.g., Sem 2 -> Sem 4).
- **Graduation:** Marking final-year students as "Alumni".
- **Liability Check:** You cannot delete a student if they have unreturned books or unpaid fines.

4. Circulation (Issues & Returns)

The core transactional module.

- **Issue Book (F1):**
 - Select Student -> Scan Book.
 - **Validation:** Checks loan limits (max 5 books) and existing fines.
- **Return Book (F2):**

- Scan Book -> System calculates Overdue Fines automatically.
- **Damage Handling:** Mark book as "Damaged" or "Lost" to apply extra penalties.
- **Renew Book (F3):** Extend the due date if the book is not reserved.

5. Transactions & Fines

- **Transaction History:** A complete log of every issue, return, and renewal.
- **Fines:**
 - Accept partial payments (e.g., Paying ₹50 of a ₹100 fine).
 - Waive fines (requires reason, e.g., "Medical Emergency").
 - Receipts are generated for all payments.

6. Reports

Generate analytical data.

- **Types:** Circulation Stats, Financial Reports, Most Popular Books, Top Students.
- **Export:** Save reports as PDF or CSV.
- **Date Filters:** View data for the Last 7 Days, This Month, or Custom Ranges.

7. Broadcast (Notifications)

Send bulk emails to users.

- **Targets:**
 - Specific Students (Search & Select).
 - **Smart Groups:** "All Overdue Students", "Final Year Students".
- **History:** View logs of all sent emails.

8. Administration (Admins & Staff)

- **Manage Admins:** Create co-admins with full access.
- **Manage Staff:** Create operational accounts with granular permissions (e.g., "Give access ONLY to Circulation").

17.3. Troubleshooting & FAQ

Q: Why can't I delete a book?

A: You cannot delete a book if any copy of it is currently **Issued** to a student. Inspect the "Manage Copies" view to find the issued copy.

Q: Why is the "Save" button disabled on Settings?

A: Critical settings (like Policy) require your Admin Password to confirm changes.

Q: "Network Error" when scanning a student?

A: Ensure you are connected to the internet. The system fetches student photos and signatures from the remote server.

Q: Where is the installer?

A: After building, the setup file is located in `Final_Fixed_Build/GPTK Library Manager Setup 1.0.0.exe`.

20. Appendices

18.1. Glossary

- **Accession Number:** A unique barcode ID assigned to a specific physical copy of a book.
- **ISBN:** International Standard Book Number (Identifies the "Master" book record).
- **IPC:** Inter-Process Communication (Bridge between Electron Main and React Renderer).
- **JWT:** JSON Web Token (Used for stateless authentication).

18.2. Third-Party Licenses

- **React:** MIT

- **Electron:** MIT
- **SQLite3:** Public Domain
- **Chart.js:** MIT
- **PDFKit:** MIT